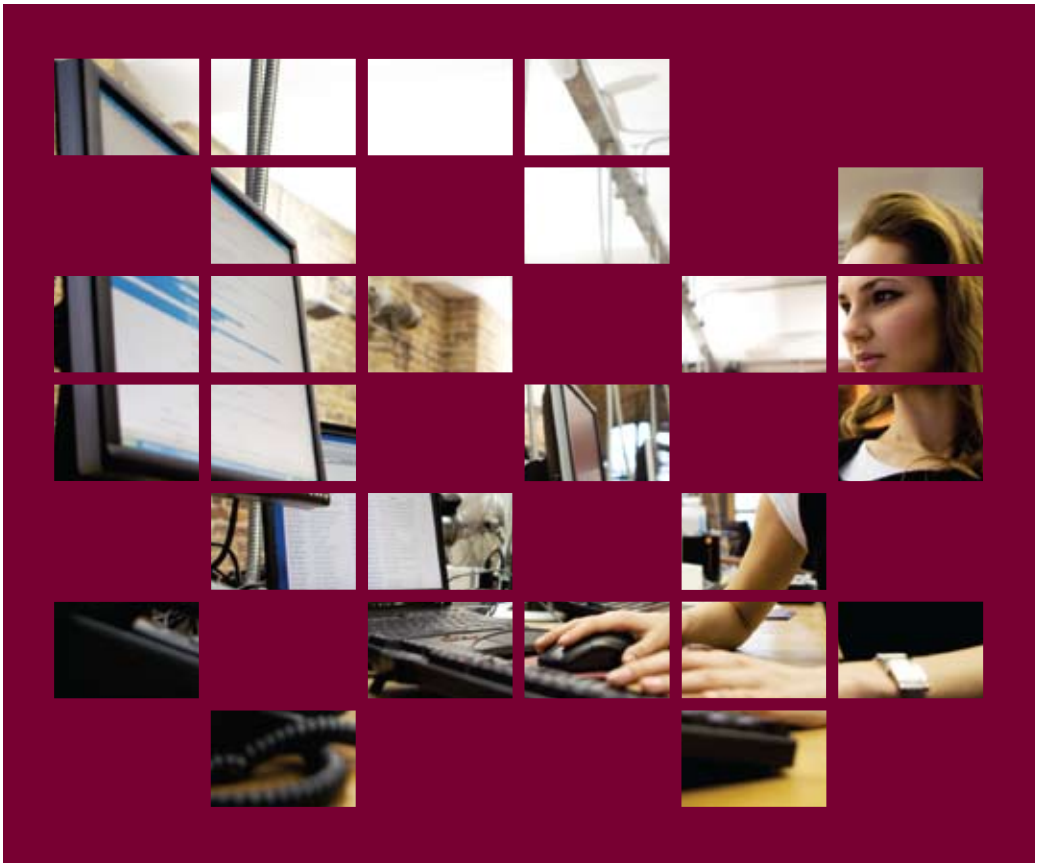


Chapter 6.
The College Student Experience

A critical part of attracting more girls and women in computer science is providing multiple ways to "be in" computer science.

—Jane Margolis and Allan Fisher[7]

Many young women graduate from high school with the skills needed to succeed in majors in science, technology, engineering, and mathematics, yet college-bound women are less likely than men to pursue majors in these fields (National Science Board, 2010). The culture of academic departments in colleges and universities has been identified as a critical issue for women's success in earning college degrees in STEM fields (National Academy of Sciences, 2007). This chapter profiles two research projects that demonstrate how improving the culture in science and engineering departments can help keep capable female students enrolled in these majors.

Jane Margolis and Allan Fisher's research on women in computer science at Carnegie Mellon University and Barbara Whitten's work on women in college physics departments found departmental culture to be a key factor in female students' decision to remain in or leave these majors. Both projects provide practical ideas for improving the climate at college for female students in STEM. These researchers demonstrate that small changes in recruitment, admissions, and course work and creating and promoting opportunities for positive interactions among students and between students and faculty can make a big difference in students' experiences.

CULTURE OF A COMPUTER SCIENCE DEPARTMENT

Margolis and Fisher conducted a four-year study of women and computing at the School of Computer Science at Carnegie Mellon University, one of the premiere schools of computer science in the United States. Between 1995 and 1999 they interviewed more than 100 students multiple times, beginning with the student's first semester in the computer science department and concluding when the student either graduated or left the major. Margolis and Fisher also held discussions with faculty, examined student journals, and observed classes. At the beginning of their study, women made up only 7 percent of the undergraduate computer

[7]Jane Margolis is a senior researcher at the UCLA Graduate School of Education and Information Studies. Through her studies of the gender and race gap in computer science, she examines social inequities in education and how fields become segregated. She is the co-author of two award-winning books, *Unlocking the Clubhouse: Women in Computing* (MIT Press, 2002) and *Stuck in the Shallow End: Education, Race, and Computing* (MIT Press, 2008). Allan Fisher is vice president for product strategy and development at the Laureate Higher Education Group. He served until 1999 as faculty member and associate dean for undergraduate education in the School of Computer Science at Carnegie Mellon University and wrote *Unlocking the Clubhouse: Women in Computing* with Jane Margolis.

science majors and were almost twice as likely as men were to leave the major (Margolis & Fisher, 2002). As the associate dean for undergraduate computer science education, Fisher was concerned about the attrition of female majors. Margolis was a social scientist with a background in gender and education and an interest in how fields become segregated and was intrigued to understand why so few women study computer science. Margolis and Fisher characterize their work as an "insider-outsider" collaboration.

Departmental culture includes the expectations, assumptions, and values that guide the actions of professors, staff, and students. Individuals may or may not be aware of the influence of departmental culture as they design and teach classes, advise students, organize activities, and take classes. Margolis and Fisher described how the computing culture reflects the norms, desires, and interests of a subset of males—those who take an early interest in computing and pursue it with passion during adolescence and into college. Margolis and Fisher point out that throughout the life cycle "computing is actively claimed as 'guy stuff' by boys and men and passively ceded by girls and women" (ibid., p. 4). This pattern of behavior is influenced by external forces in U.S. culture that associate success in computing more with boys and men than with girls and women and often makes women feel that they don't belong simply because of their gender. In an interview with AAUW, Margolis explained: "There is a subset of boys and men who burn with a passion for computers and computing. Through the intensity of their interest, they both mark the field as male and enshrine in its culture their preference for single-minded intensity and focus on technology." Within that environment this particular male model of "doing" computer science becomes the measure of success; however, because young women and men often have different experiences with computers and different motivations to study computer science, this model can alienate women.

Many young men in computer science report having had an immediate and strong engagement with the computer from an early age. That engagement intensified in middle and high school and led the young men to declare a computer science major. On the other hand, many women who are interested in computer science and have similar talent do not report a similar experience. Many of these young women report a more moderate interest in computer science, especially early on, that builds gradually. Distinguishing between an interest in computer science and an interest in computers and technology is important. Historically girls had less interest in and experience both with computers and in computer science. Today women and men are interested in and equally likely to use computers and technology for educational and communication purposes (Singh et al., 2007), but the gender gap in the study of computer science remains.

About three-quarters of the men that Margolis and Fisher interviewed fit the profile of someone with an intense and immediate attraction to computing that started at a young age,

in contrast to about one-quarter of the women in their study. Fisher explained, "There is a dominant culture of 'this is how you do computer science,' and if you do not fit that image, that shakes confidence and interest in continuing." According to Margolis and Fisher (2002, p. 72), "A critical part of attracting more girls and women in computer science is providing multiple ways to 'be in' computer science."

Other researchers concur that feeling like a misfit can lower confidence, especially among women. Female undergraduates often report lower confidence than male undergraduates report in their math or science abilities and their ability to succeed in their STEM major (Seymour & Hewitt, 1997; Cohoon & Aspray, 2006). Even among women and men who have similar grades, women in computer-related majors are less confident than their male peers of their ability to succeed in their major (Singh et al., 2007). Margolis and Fisher also found that the group of female computer science majors who were brimming with confidence and excitement about their major in the earliest interviews were no longer "buzzing" by the second and third semester. Margolis and Fisher (2002, p. 92) argue, "The decline in women's confidence must be acknowledged as an institutional problem."

Curriculum can also play a role in signaling who belongs in the major. Computer science programs often focus on technical aspects of programming early in the curriculum and leave the broader applications for later. This can be a deterrent to students, both female and male, who may be interested in broader, multidisciplinary applications and especially to women, who are more likely to report interest in these broader applications. As with many changes, Margolis and Fisher found that many men, as well as women, might benefit from a redesigned computing curriculum. In their interviews with Margolis and Fisher, male computer science majors also expressed an interest in the broader applications of computer science; therefore, the researchers argue that defining computer science broadly expands its appeal to both women and men. In an interview with AAUW, Margolis emphasized:

> It is really important to redefine or re-envision [what we mean by computer science] because for so long people thought of computer science as focused on the machine and hacking away at the computer. But computer science is now a discipline that is playing a key role in invention and creation across all sorts of disciplines from biological science to film and animation, and that expansion of the field and how critical it is across all disciplines increasingly makes it more meaningful.

Culture can also influence what faculty, students, and others in the department believe a computer science major should look like. The iconic image of the computer science major was for

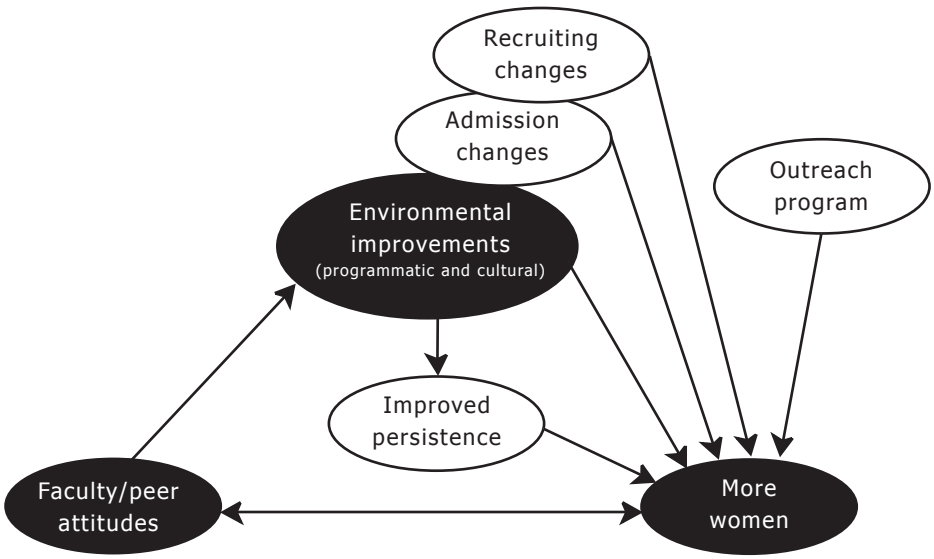
many years the asocial "geek"—a person in love with computers, myopically focused on them to the neglect of all else, at the computer 24/7. Although Margolis and Fisher found that female and male students agreed that the overwhelming image of a computer science major at Carnegie Mellon is the geek, more than two-thirds of the women and almost one-third of the men said that the image did not fit them. Yet the geek image was especially damaging to women. One-fifth of the women interviewed questioned whether they belonged in computer science because they did not have that intense connection and focus that they observed in their male peers. According to Margolis and Fisher (2002, p. 71), "The rub for women in computer science is that the dominant computer science culture does not venerate balance of multiple interests. Instead the singular and obsessive interest in computing that is common among men is assumed to be the road to success in computing. This model shapes the assumptions of who will succeed and who 'belongs' in the discipline."

Today Margolis and Fisher agree that the geek image has evolved since they concluded their study. As computers and computing have become integrated into other disciplines like digital media, including music and film, the geek image has shifted from that of a socially isolated person to include a chic geek image where it can be cool to know about computers and computing. "Nevertheless, although the geek image and focus have softened, it is still an issue that departments deal with," Margolis and Fisher said in the AAUW interview.

These factors—the expectations that go along with being a computer geek, coupled with a male-dominated environment and the focus on programming or hacking—can all contribute to an environment and culture that are major deterrents to the recruitment and retention of women. Margolis and Fisher (2002, p. 6) insist that the goal should not be to fit "women into computer science but rather to change computer science." The majority of the women interviewed, including those who remained in computer science, expressed dissatisfaction with the culture of the discipline. Margolis and Fisher stress that departments should pay attention to the student experience to improve recruitment and retention of women and that having diverse faculty is also critical (see figure 19).

As a result of Margolis and Fisher's work, the School of Computer Science at Carnegie Mellon implemented several changes that helped create a more welcoming culture and improved the recruitment and retention of female students. The proportion of incoming female students increased from 7 percent in 1995, the first year of the study, to 42 percent in 2000. Retention of women also improved during that period (Margolis & Fisher, 2002).

Figure 19. Process for Improving Recruitment and Retention of Women in Computer Science



Source: Margolis, J., & Fisher, A., 2002, *Unlocking the clubhouse: Women in computing* (Cambridge: Massachusetts Institute of Technology), p. 139.

RECOMMENDATIONS

Margolis and Fisher offer computer science departments the following recommendations. These could also apply to departments in other STEM disciplines that want to attract and retain diverse and talented students.

- **Perform outreach to high schools.**

  From 1997 to 1999 Carnegie Mellon University hosted a summer institute for advanced placement computer science teachers to prepare them to teach programming and provide them with gender equity instruction to help increase the number of girls taking high school computer science. Not only did participating teachers report success in recruiting more girls, but an increasing number of talented students, both female and male, from the participating high schools applied to the Carnegie Mellon School of Computer Science, which supported the university's recruitment of a more diverse student population.

- **Send an inclusive message about who makes a good computer science student.**

  Carnegie Mellon changed the admissions policy that gave preference to applicants with a lot of previous programming experience once the university realized that this was not a key to student success. This change sent a more inclusive message about who could be a successful computer science student and helped Carnegie Mellon recruit more women with no change in the quality of the applicant pool.

- **Address peer culture.**

  Peer culture within a department has a tremendous effect on students' experiences and is determined primarily by how students treat and relate to one another. Faculty should, therefore, pay attention to peer culture to ensure that no student clique (for example, hackers) dominates or becomes the ideal way of being in the major.

- **Broaden the scope of early course work.**

  Offer introductory courses that show the wide variety of computer science applications and a curricular pathway to complete the degree that does not assume years of computer science experience.

WHAT WORKS FOR WOMEN IN UNDERGRADUATE PHYSICS?

Departmental culture can also be a barrier to women in physics. Physics continues to be one of the most male-dominated of the STEM disciplines, with women earning only 21 percent of bachelor's degrees in 2006 (National Science Foundation, 2008). Barbara Whitten,[8] a professor of physics and women's studies, collaborated with a team of researchers to examine what works for women in undergraduate physics departments.

Whitten began her study in late 2002. For the first phase of the study, she and her colleagues visited nine undergraduate-only physics departments in the United States. In five of those departments women made up about 40 percent of the graduates, while in the other four departments women's representation among graduates was closer to the national average (about 20 percent at the time). The first group was defined as "successful," and the second group was defined as "typical." Whitten and her team wanted to know what set successful

[8]Barbara Whitten is a professor of physics at Colorado College. Her primary research is in the area of theoretical and computational atomic and molecular physics, and she has worked on problems in laser plasmas, Rydberg atoms, and low-energy electron collisions. She is also interested in gender and science, and for the past decade she has focused primarily on the experience of undergraduate women in physics. She has conducted research on what makes a physics department female-friendly in a project called What Works for Women in Physics?

departments apart from more typical departments. To answer this question, they gathered data from each department through interviews with faculty, students, administrators, and staff and observed courses and labs during two days in each department. The researchers found that the major difference between successful and typical departments was departmental culture (Whitten et al., 2003).

Similar to Margolis and Fisher, Whitten and her team found that many different factors help create a departmental culture and environment that are supportive and welcoming to female students. According to Whitten, most typical departments do some of these things, but successful departments do more of them, and they do them more consistently and more personally. Specifically, Whitten and her team found that the most successful departments supported activities and events that fostered a broader culture that was inclusive. Successful departments integrated students into the department soon after they declared a physics major and reached out to students taking introductory courses who might potentially major in physics. Successful departments often had a physics lounge and sponsored seminars, trips, and other social events. These activities provided opportunities for students to learn more about different applications of physics and career opportunities but also provided opportunities in which faculty and students could interact more informally to forge relationships.

Whitten was especially impressed with the model of historically black colleges and universities (HBCUs) for creating effective and supportive departmental cultures that help recruit and retain female science majors. HBCUs produce a disproportionate number of African American female physicists, and more than one-half of all African American physics degree holders, female and male at all levels, graduate from HBCUs (Whitten et al., 2004). Whitten says that HBCUs do many of the things that create a female-friendly department and do them exceptionally well. HBCUs support all their students, including women. As Whitten puts it, "You don't have to aim at women to have benefits for women."

HBCUs do one crucial thing that Whitten's team did not observe at other schools they visited in the first phase of the study: the schools provide a path toward a degree for students who do not come to college fully prepared to be physics majors. "Most schools don't recognize a category of student who would like to be a physics major, is interested in physics, and might be good at physics but who does not have the preparation straight from high school," Whitten told AAUW. The typical model is someone who has decided in high school that she or he wants to be a physics major and declares the major in college. HBCUs were the only schools that provided an alternative path to the major. Whitten believes that "if we could make a path like that in all schools, we would increase the diversity of physics majors." This is an example of how a department can change its approach to recruitment and increase diversity. Many students who do not have adequate high school preparation in physics can succeed at the college level if provided a path.

In the second phase of their research, Whitten and her team visited six physics departments at women's colleges and found that they and the HBCUs had a similar philosophy of student recruitment. Physics faculty at women's colleges know that few women come to college intending to major in physics, so active recruitment is a necessity. This reality forces faculty to think of "pathways rather than pipelines" and challenges the notion of a singular, linear route to becoming a physicist, which is more likely to reflect a white male experience (Whitten et al., 2007).

RECOMMENDATIONS

Whitten's research suggests that a female-friendly physics department should adopt all or some of the following practices:

- **Sponsor departmental social activities.**

  Seminars, lunches, and social events help integrate students into the department. Departments should also make an effort to invite potential majors to enroll in introductory courses and participate in social activities.

- **Provide a student lounge.**

  A lounge and other informal spaces in which undergraduate majors can interact outside of class can help integrate students and make the department feel more inclusive. Be sure that the lounge is welcoming and open to all students.

- **Actively recruit students into the major.**

  Provide interested and talented students who arrive at college underprepared or unsure that they want to study physics, or any other STEM subject, a pathway to the major. Offer introductory courses that appeal to students with different levels of physics preparation or background. The work of faculty at HBCUs to provide a pathway into physics for underprepared students is an excellent example of how critical this is to identifying and recruiting talented STEM students from more diverse backgrounds.

- **Sponsor a women-in-physics group.**

  In a male-dominated field like physics, having an informal group of female faculty and students can help female students. Groups like this can sponsor a variety of social and professional activities and, if possible, should be organized by a female faculty member as part of her departmental service, not as a volunteer activity.