Diversity in Computing: Why It Matters and How Organizations Can Achieve It

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Computing-related jobs are interesting, well-paying, secure, and abundant, so why aren't more women working in this creative field that produces the technology that is central to our daily lives?

Although women comprise 57 percent of the professional workforce, they make up only a quarter of the computing workforce (www.bls.gov/cps/cpsaat11.pdf). As Figure 1 shows, the female representation in engineering is even lower, hovering around 14 percent for the past decade. According to the US Bureau of Labor Statistics, women of color are more severely underrepresented, with Asian-American women constituting about 4 percent of women in computing, African-American women 3 percent, and Hispanic-American women 1 percent (www.bls.gov/opub/ee/2012/cps/annual.htm).

Women who are in the computing and engineering workforce report that they are often assigned executor roles rather than creator roles, thus discouraging their hands-on participation.[1] US patenting data suggest women's participation in the inventive aspects of the profession might be improving, but it still lags well behind men's participation. For example, the number of patents held by females increased from 2 percent of all patents in 1980 to 8 percent in 2010 (www.ncwit.org/patentreport).

If we assume that technological innovation is a product of disruption—a result of literally thinking differently than the norm—it follows, then, that a development team should consist of members with substantially different perspectives. Recruiting, retaining, and promoting more women and other historically underrepresented populations in academia and industry will not only enhance innovation but also help create greater social equity, giving these populations equal access to high-paying and intellectually satisfying jobs.

MISSED OPPORTUNITY

As a society, we lose out on potential innovations when we do not have a diverse workforce fully participating in technology creation.[2] Research shows that with proper training and management, diverse teams—in terms of culture, race, and gender—can improve creativity, problem solving, productivity, and several other important outcomes. A large study spanning 21 different companies, for example, showed that teams with 50:50 gender membership were more experimental and more efficient (www.london.edu/assets/documents/facultyandresearch/Innovative_Potential_NOV_2007).

In theory, the computing profession should attract the wide variety of people needed to reap positive performance benefits because it is a stable and growing field. In

Published by the IEEE Computer Society

2009, when the overall unemployment rate in the US was 9.7 percent, the unemployment rate for computing occupations was only 5.4 percent; for women employed in these fields, it was even lower, at 3.8 percent (ftp://ftp.bls.gov/pub/special.requests/lf/aa2010/pdf/cpsaat25.pdf). Because of the highly valued skills required, employers pay well: the median annual wage for computing occupations in 2010 was $73,720 (www.bls.gov/oes/current/oes_nat.htm). And given the ubiquity of computing in our everyday lives, the strength of the computing profession is likely to persist. The Bureau of Labor Statistics predicts that from 2010 to 2020, there will be a 22 percent increase in computing jobs, compared to a 14 percent increase in jobs overall (www.bls.gov/opub/mlr/2012/01/mlr201201.pdf).

Unfortunately, the computer science major is not popular enough among students to graduate sufficient numbers to fill the many projected job openings. A 2007 College Board survey of 1.6 million college-bound high school students taking the SAT exam found that only 2 percent intended to major in computer science and 8 percent in engineering (http://research.collegeboard.org/content/archived-data). Four years later, according to the National Center for Education Statistics, only 2 percent of US bachelor's degrees were in computing-related fields, and even fewer were specifically in computer science (https://surveys.nces.ed.gov/ipeds). The statistics for women are even more discouraging: of all the bachelor's degrees earned by women, only 0.8 percent were in computer and information sciences.

When women do not study computing in college, they are unlikely to pursue it as a career. Consequently, the homogeneous classrooms in the computing departments at colleges and universities mirror the cubicles and offices of industry.

CURRENT SNAPSHOT

Changing this scenario requires looking more closely at women's participation in computing from high school through the workforce, examining the barriers women face, and pointing to ways organizations can create much-needed changes.

At the high school level

Most high school students are unaware of computing as a field of study or profession, and they have had little experience with or exposure to it. Girls in particular typically are not encouraged by their parents, teachers, and counselors to pursue computing or engineering subjects. Moreover, media portrayals of these technical fields generally depict their practitioners as predominantly male and socially deficient.

Consider these statistics: whereas 2 percent of male SAT exam-takers intend to major in CS, 0.4 percent of female SAT exam-takers have the same intent (http://research.collegeboard.org/programs/sat/data). Of the nearly 2 million Advanced Placement (AP) exam-takers in 2011, more than half were female, but only 18 percent of those who took the computer science (CS) AP exam were female (http://research.collegeboard.org/programs/ap/data/participation/2011). Although these statistics describe only the high school level, they help determine the gender composition of the field later on. AP research indicates that students taking an AP exam in a given subject area are more likely to take college coursework in that area (http://research.collegeboard.org/publications/content/2012/05/four-years-later-longitudinal-study-advanced-placement-students-college). As Figure 2 shows, each year since 1999, the CS AP exam has consistently had the lowest female percentage of any of the 37 AP exams, hovering at 18 percent or lower.

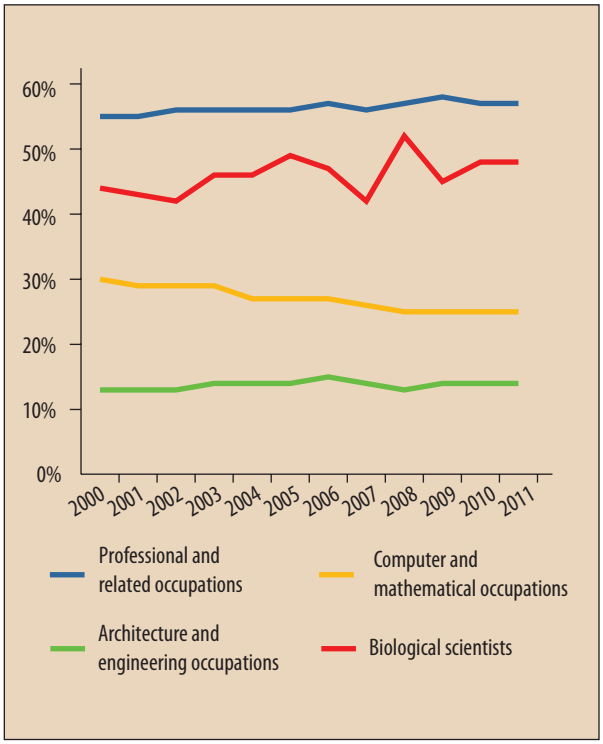

Figure 1. Female representation in select science professions, 2000-2011.

Because of the low numbers of students exposed to and interested in computing in high school, the girls who take these classes find themselves confronted with a very different gender composition than in their other classes. One high school girl shared her experience of repeatedly having to prove herself:

> Last year, I was the only girl in our advanced programming class, so the gender ratio is something that I find myself confronted with every day. Most people don't realize how this ratio is translated into real life, as numbers and charts sometimes

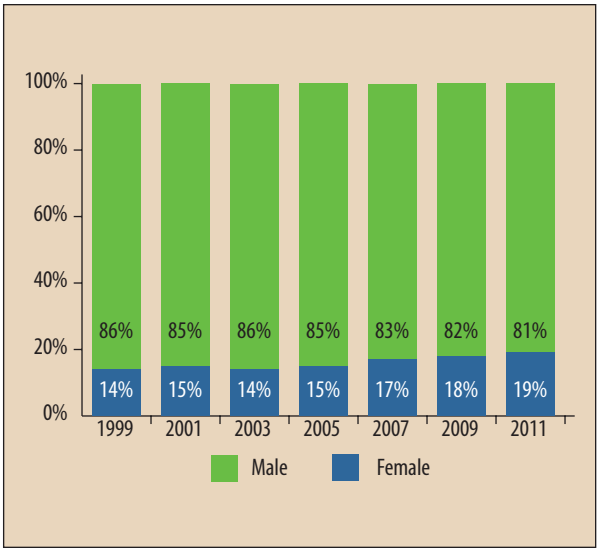

Figure 2. Percentage of Advanced Placement computer science exam-takers by gender, 1999-2011.

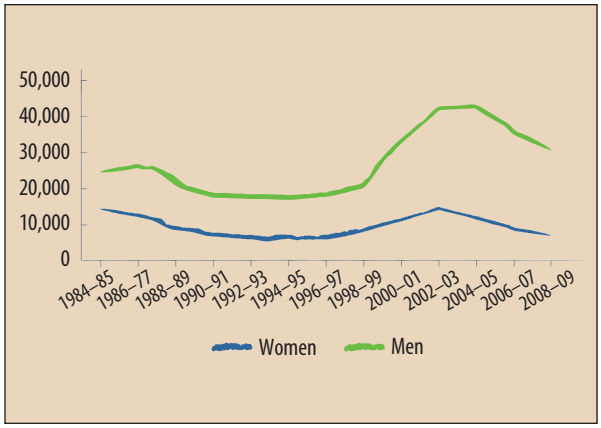

Figure 3. Bachelor's degrees in computer and information sciences, by gender: a longitudinal look.

> fly over people's heads. But I know that ratio, I live that ratio. I was one of four girls on our robotics team, and I really do feel the need to prove myself in day-to-day activities, as if the guys in the room doubt me.

Those who survive the gauntlet might emerge that much stronger, but consider all the brilliant and capable girls who opted not to put themselves into such an unwelcoming environment.

At the postsecondary level

According to the National Center for Education Statistics, women earned 57 percent of all undergraduate degrees and half of all math and science degrees in 2010 (www.ncwit.org/scorecard). In that same year, women earned only 18 percent of computer and information sciences undergraduate degrees. While these percentages have held relatively steady since 2007, Figure 3 shows that the gap between the number of females and males receiving computing degrees has widened since 2000.

Currently in the US, rigorous computing classes are not available in many high schools—and even if they were, an insufficient number of qualified teachers is available to prepare students (www.acm.org/runningonempty). Consequently, female students end up not choosing to study computing or engineering in college because they have had little prior exposure to or experience with computing, and little or no encouragement from adult influencers and peers.

Present in only small numbers in a department, female undergraduates often find themselves either as the only female in a class or one of just a few. This can, of course, be alienating. One young woman described her experience at a public university:

> Three years ago, as a timid freshman, I nervously entered [a public university] to find I was the first girl at my college to ever pursue a degree in computer science. Furthermore in my core classes, the ratio of men to women is approximately 20:1, a figure more biased toward men than the national average. However, statistics alone can't describe the loneliness I felt every day walking into classes dominated by men. To make matters worse, freshman year, many of my male classmates didn't take me seriously as a peer, and actively ostracized me from their groups. Had I not had any support, I am certain that I would have dropped my computer science classes and opted for a more female-friendly program.

This young woman's story is representative of many other female students who have both the talent and passion for computing, but are left feeling like they do not belong.

In industry

It can be disconcerting to be a woman in a male-dominated field. People tend to perceive a person who is clearly identifiable as an "out-group member" through lenses influenced by stereotypes (http://anitaborg.org/files/Climbing_the_Technical_Ladder.pdf). Stereotyping is most likely to occur when there is a very apparent out-group member—one female on an otherwise all-male team will be the subject of more stereotyping than any of the male team members and might be perceived as less technically adept.[3]

Now-classic studies have demonstrated that there is a tendency to view women in male-dominated fields, such as computing and engineering, as either competent or likable but not both, and have revealed that these perceptions have a deleterious effect on women's careers.[4,5] The women themselves are subject to what is known as *stereotype*

threat, where they perceive themselves as less than capable because the active stereotypes at play suggest that they are, and, therefore, they actually don't perform as well. These unconscious biases operate in male-dominated classrooms and workplaces despite our best intentions.

There are other biases at play in the workplace as well. This story from a woman with a senior technical title explains why companies lose hard-working, female experts by adhering to an old-school work philosophy:

> As the most senior woman on an engineering team of a fast-paced start-up, I loved my job. The thrill of creating something, the ups and downs of getting funding, the tough competition in the space—there's nothing like it. So when I became a mom, I vowed not to let my team down. I'd arrive at 8 a.m. having dropped my kids at daycare, and got right to work. Around 10, 10:30, the single guys would start to show up. They'd get their coffee and breakfast and sit at their desks, perusing their favorite blogs and news sites. After a stint of work, it would be lunchtime; I'd eat at my desk, and they would either go out or go to the gym. By midafternoon, as I was racing to get things done before picking up my kids, many of my colleagues would gather for a round of frisbee or foosball or ping-pong. At the stroke of 5, I'd be off to pick up my kids and have dinner with my family. Usually by 9, I'd log back on and see how my teammates felt about my day's contributions.
>
> Not long ago, I was up for a promotion; given my peer reviews and my experience, it was a slam dunk. But my manager doubted my commitment. He said, "When I make the rounds at 9 p.m., I see many of your teammates still working while eating pizza at their desks. I know you're often online, but that's not the same." I told him, "Of course, they're still at their desks at 9 p.m., they've only put in six hours of work by that point." That's when I knew I was out of there. If my manager can't tell the difference between face time and productivity, I'll never get what I deserve.

This scenario demonstrates that it is not only family-friendly policies that make a difference for retaining women but also an ethic that recognizes and prizes different values and work styles (www.ncwit.org/supervising).

Among faculty

As Figure 4 shows, the female percentage of computing faculty has increased substantially in all ranks since 2002. Still, the higher the faculty rank, the fewer the women. Even allowing for academic hiring and promotion practices that result in slow changes in the population of full professors, computing lags behind the rest of academia, where women comprised between 20 and 30 percent of full professors in 2006, with little evidence of a significant change five years later.[6]

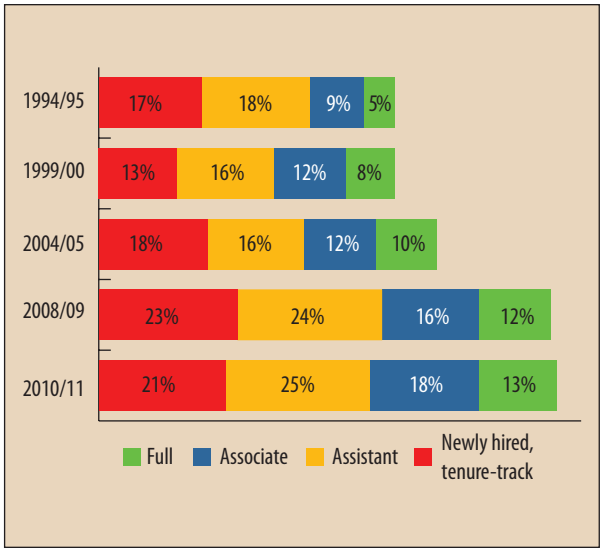

Figure 4. Female percentage of computer science faculty at PhD-granting institutions, 1995-2011.

Despite being a smaller proportion of the population, women with doctorates in computing have been especially productive authors. On average, female computing PhDs wrote one more paper per year for the past 50 years than did male computing PhDs.[7] It is not clear what drives these high rates of productivity, but it is clear that women with computing doctorates actively contribute their creative knowledge to the field.

TAKE ACTION

Computing needs additional creative thinkers and problem solvers. While diversifying the potential workforce would address this issue, the question then becomes what could be done to encourage individuals from those underrepresented populations to consider computing as a field of study or career? The problem can seem daunting, but computing academics and professionals can take several actions to remedy the generally low interest in computing.

Raise awareness at the high school level

Many university computing departments and corporations already have outreach programs to local-area high schools. Sending representatives to schools to speak about the field in a way that appeals to high school students can be a good way to raise awareness and recruit.

The National Center for Women & Information Technology (NCWIT) offers a variety of materials that have been successful at raising awareness and increasing knowledge among high school students, girls in particular. These free materials include hands-on computing activities and intriguing demonstrations that can be done in a classroom setting.

Three examples of such materials include Computer Science-in-a-Box: Unplug Your Curriculum; Outreach-in-a-Box: Discovering IT; and Roadshow-in-a-Box: Capitalizing on Models for Outreach (www.ncwit.org/resources). Users of these programs have found it helpful to have "near-peers" deliver the presentations at local high schools—undergraduates or younger employees can forge a stronger connection with students. Postpresentation feedback from teachers can help improve outreach for the next time.

To make a large-scale difference, individuals can advocate for more-rigorous computing classes locally or even at the national level. Offer to make a presentation to your school board or join the cause by volunteering with Computing in the Core (CinC) or writing to your state or local leaders (www.computinginthecore.org). CinC provides an advocacy toolkit that contains a sample letter you can customize.

Workplaces need to strive with equal intensity to retain those technical women already in place.

Recruit and retain at the university level

Universities and colleges can recruit new students not only from high schools but also from within their own campuses as well. Targeted outreach to incoming freshmen, undeclared majors, and students with high math aptitude can bring in capable students who otherwise might not have considered a computing major.

Curriculum reform can make a big difference in retaining those students once they are in the computing department. Many computing departments, including those at Indiana University, Harvey Mudd, Stanford, Virginia Tech, and Cornell, have changed their introductory course to make it more accessible, meaningful, and relevant to students' lives. Some departments have found success in separating nonmajors from majors in these introductory courses, or separating those with previous experience from those without. While the course content remains the same for these groups, the outcomes are markedly better for the less experienced students.[8] Explicitly connecting these introductory and subsequent courses to intriguing and satisfying careers encourages students to consider the computing major.

Research shows that subtle pedagogical shifts on the part of individual instructors can also help retain students, with early and specific feedback on assignments and on individual progress having the biggest impact. Students who are a minority in a class can more easily suffer from a lack of confidence stemming from a feeling of not belonging.[9] A large body of research suggests that female students are more likely than male students to lose confidence in their ability to earn good grades even when their performance is equal to that of the male students.[10,11] Routine, positive faculty-student interaction in general can help all students feel they belong in the department, which will go a long way toward retaining them in the major when courses become more challenging.

Information about all of these practices is provided in free, downloadable NCWIT documents, such as "Strategic Planning for Recruiting Women into Undergraduate Computing: High Yield in the Short Term," "Key Practices for Retaining Undergraduates in Computing," and "Top 10 Ways You Can Retain Students in Computing" (www.ncwit.org/resources).

Reform the workplace

From policy implementation to supervisor behavior changes, technical workplaces can provide significant help to increase the presence and contributions of women and other historically underrepresented populations. Actively recruiting them as interns and junior employees, for example, can help create a pipeline of new candidates. During the hiring process, being explicitly open to atypical education or experience while still seeking key job-related skills can help, as can documenting the necessary job skills that will be used to score potential candidates.

Workplaces need to strive with equal intensity to retain those technical women already in place. Establishing, implementing, and respecting family-friendly work schedules that include flex-time and telecommuting can keep talented women (and men) from leaving midcareer. Active sponsorship and visible promotion of technical women and people of color help to create an environment that feels supportive to employees in the minority populations (www.ncwit.org/thefacts).

Individual supervisors can improve the ability of workplaces to recruit and retain technical women, but strong policy statements and support from executive leadership are important for ensuring that the workplace culture supports diverse employees.

These practices—along with others that have been shown to bring more women into the computing workforce and keep them there—are described in NCWIT materials, particularly "Strategic Planning for Increasing Women's Participation in the Computing Industry" workbook, "Top 10 Ways Managers Can Retain Technical Women," and "The Supervising-in-a-Box" series, all available online.

Make changes thoughtfully

At the high school and postsecondary levels, addressing unconscious biases in classrooms and assignments is critical. Even if the appropriate policies are in place, faculty must be made aware of the ways they might unconsciously

affect recruitment and retention. While the establishment and implementation of policies are crucial, recognizing and avoiding bias in recruitment, hiring, performance reviews, and promotions are keys to making enduring cultural shifts in the workplace.

Even if you are successful at recruiting for diversity, you might still face challenges. Diverse teams and classrooms must be managed appropriately to head off the inevitable stereotypes and in-group/out-group thinking and behaviors that come from bringing together different types of people. A strong focus on the task or problem can help ward off any potential conflict that might arise from diverse individuals working together.[12] It is also important not to assume that one person can represent an entire race or gender.

Set aside time during a low-stress period at work to take one step toward diversifying computing, whether it is reviewing your CS introductory curriculum, talking with your HR representatives, or making a presentation in your local high school. By taking action, you will be helping to create a more plentiful, more diverse pool of computing academics and professionals.

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