Diversity in the IT Workforce: Precursors in Education and Challenges

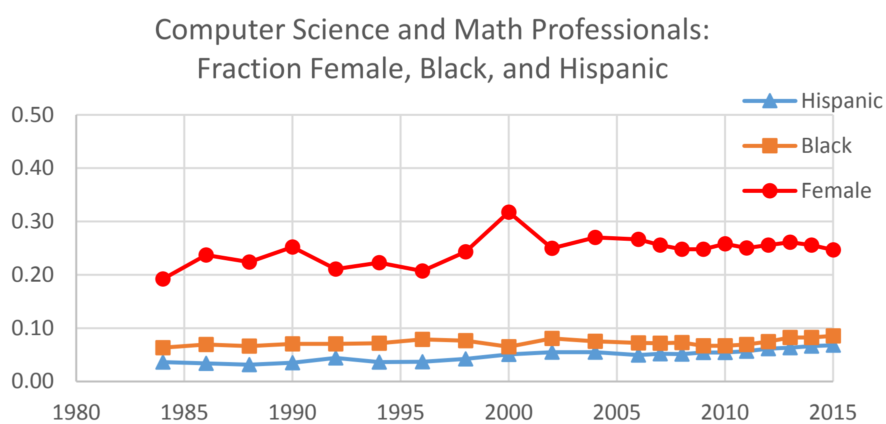
Glenn Ellison

If we are going to solve tomorrow's challenges, we must come together to inspire young people everywhere with the promise of technology. We can't leave anyone out.

Satya Nadella

The underrepresentation of women and minorities in the IT workforce is a longstanding concern. It is troubling to IT firms both because they lose the potential benefits of a diverse workplace and because the failure to attract talented women and minorities contributes to the overall shortage of highly trained workers. Despite a number of efforts to diversify the IT workforce, strikingly little progress has been made in the 21st century. Making substantial progress on underrepresentation in the workforce will likely require a long sustained effort on multiple fronts. I note here that the lack of progress in the IT workforce mirrors a lack of progress in education. This suggests that confronting the challenges of underrepresentation in both university and secondary education in computer science will be necessary.

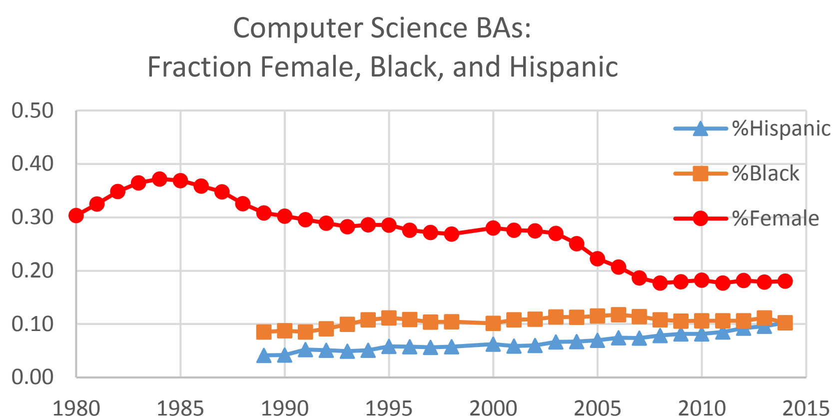
The figure below illustrates the slow progress in diversifying the IT workforce. It graphs the fraction female, Hispanic, and black among workers classified by the National Science Foundation as "Mathematical or Computer Scientists."[1] Only about one-fourth of the workers in these occupations are female, and this fraction has held strikingly steady since the early 2000s. There have been increases in the underrepresented minority population, and an increase in the last 3 years in encouraging, but much of the longer trend just mirrors trends in the US labor force. For example, between 2000 and 2015 the fraction Hispanic in the mathematical and computer scientist category increased from 5.1% to 6.8%, but at the same time the fraction Hispanic in the full US workforce increased from 12.1% to 16.4%.



[1] This category includes a variety of computer industry occupations including software engineers, database administrators, and computer support specialists, as well as a few smaller occupations like actuary, statistician, and mathematician.

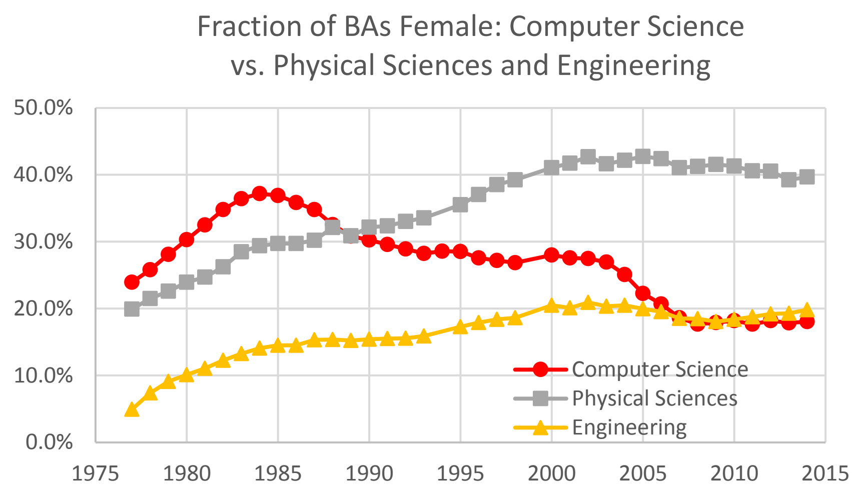
Looking back: diversity in college programs

The lack of success in diversifying IT workplaces mirrors another lack-of-success story: there has been little progress in diversifying computer science programs at US universities. The figure below presents comparable diversity statistics for the set of students graduating from US universities with bachelor's degrees in computer science, again compiled from various National Science Foundation reports. Black representation rose in the 1990s but has declined in the last decade. Hispanic representation has had a slow but steady increase. Each group now comprises about 10% of recent BAs. But both groups remain underrepresented and the increase in Hispanic representation just follows the trend in the overall college population. The trend in female representation is more striking. An older increasing trend had female representation up to 37% by 1984, but the trend then reversed and the main story of the last 30 years has been a long decline to about half of the peak level. The decline in female representation is noticeably steep in the late 1980s and mid 2000s. Overall, the underrepresentation suggests that one focus of attempts to diversify the IT workforce must be to diversify computer science education.



There is a vast literature on women's underrepresentation in STEM fields. Ceci, Williams, and Barnett's (2009) survey article on the topic, for example, contains about 400 references. Papers in this literature have explored a wide variety of potential causes for underrepresentation including biological differences, childhood influences, treatment by teachers, reluctance to enter male-dominated fields, biases in evaluation, family demands, etc. There is a wealth of evidence illustrating the relevance of many of these mechanisms in some context. And many seem like they could be relevant across all STEM fields.

The outcomes in college computer science, however, are not like those of all other STEM fields. In the 1970s and early 1980s they were similar: at the time women were gaining ground in many formerly male-dominated fields. By the mid 1980s women had already reached near parity in several STEM fields including biology and mathematics. In most other fields where women had traditionally been farther behind, they were gaining. Computer science, however, diverged from this path in the mid 1980s. The figure below illustrates this by comparing computer science with physical sciences and engineering, again using data from the NSF. In engineering and the physical sciences the fraction of female BAs continued to rise for another 20 years after the fraction of female computer science majors started to fall. It is only in the last decade that the trends have again become similar with all three fields experiencing a leveling off. The uniqueness of the computer science experience does not imply that it is not important to address the many obstacles to women's workplace success that have been noted in other fields. But it does suggest that it will be important to also address challenges unique to computer science.



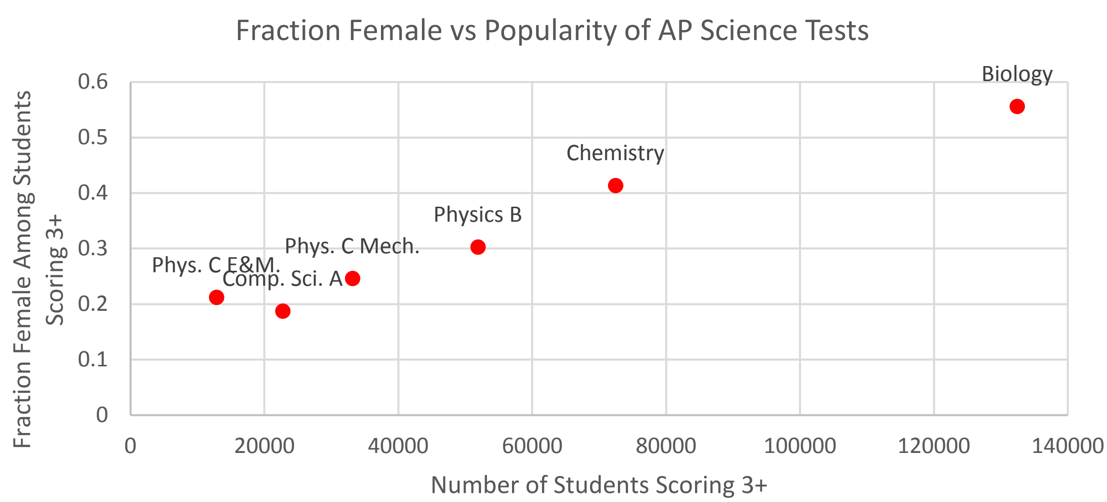
Why has the experience of computer science been so different from the experience of other STEM fields at the undergraduate level? There is no consensus. Some have pointed to the early 1980s as a time when popular culture developed an image of the single-minded, poorly socialized computer geek that did not comport with many women's self-image and aspirations. Also perhaps noteworthy are when the declines occurred: the mid 1980s is when students started to arrive on campus having had experience programming personal computers; and cohorts graduating in the mid 2000s were the first to have gone through high school after the dot-com boom. Young women have been noted to have lower self-assessments of their mathematical ability than comparably accomplished young men, and this can deter them from entering technical fields (Correll, 2001). Increased pre-college exposures to computers could have shifted the freshman experience from one where male and female students arrived on campus equally inexperienced in computers to one where freshman women were or felt behind.

Looking further back: diversity in advanced high school work

Students are more likely to do well in college if they are well prepared in high school. Even apart from the self-confidence effects noted above, students are more likely to pursue and persist in majors for which they are well prepared. Hence, it is presumably very relevant to what we see in college that fewer women and minorities enter college with strong computer science backgrounds. For example, in 2014 the population of students with passing grades (3+) on the AP Computer Science A exam was just 18.7% female, 2.6% black, and 5.6% Hispanic.

The underrepresentation of minorities is not hard to understand: access to high-quality high school computer science classes is limited. In 2010 fewer than one-tenth of US high schools had any student take the AP computer science exam, and computer science classes are disproportionately found in schools serving students of high socioeconomic status. The 10% number probably greatly overstates the number of high-quality AP classes. In Massachusetts, for example, 135 public and/or charter schools had at least one student take the AP Computer Science A exam in 2015. However, only 49 of them had at least 10 students take the exam, suggesting that many of the other schools may not have offered an AP Computer Science class. And a number of those 49 had very low pass rates suggesting that the courses they did offer may not have been preparing students well for the exam. (The bottom quartile of the school level pass rates was 20% whereas the top quartile pass rate is about 90%.) In a recent joint paper with Parag Pathak (Ellison and Pathak (2016)) we have also noted another relevant challenge. Just in the last few years a number of US public school systems have abandoned race-based affirmative action admissions policies. Given that many large urban systems have traditionally offered advanced classes only in a few magnet schools, this may be an additional obstacle to increasing access for talented minority students.

The male-female gap in high school computer science course taking is not directly attributable to girls not having access to courses. Here, it is noteworthy that the gender gap in AP course-taking is much larger in some STEM subjects than others. The figure below provides an illustration. Graphed on the y-axis is the fraction female among students with passing scores (3+) on each exam. Girls received the majority of such scores on AP Biology and over 40% of them on AP Chemistry. The fraction female is much lower in physics and computer science.



Why are outcomes so different? One potentially relevant observation is that the AP courses with smaller gender gaps are taken by many more students. This in turn may in part reflect how high school programs are structured. A first biology course is usually required of all students and taken early in high school. Courses in computer science and mathematically-rigorous physics courses, in contrast, are usually not required and are taken later if at all. High school girls in general are doing very well in meeting expectations for success: they get better grades than boys; take at least as many advanced courses, etc. It may be that the simple the difference in whether it is expected that good students take some course makes a very big difference in the gender gap.

A paper of mine with Ashley Swanson (Ellison and Swanson (2010)) has some related findings. Our work studies the gender gap in high school mathematics competitions. One thing we note is that the gender gap in these contests is larger than the gender gap in SAT scores when we look at comparably high performance levels. This indicates that many more high-ability girls are choosing not to participate. Beyond this, we note that when we look at extremely high performance levels, the gender gap is smaller at the highest-achieving high schools. One explanation would be that more girls at the high-achieving schools may be pursuing advanced math because they can do so as part of a like-minded community. This also suggests that the gender gap in advanced computer science coursework may narrow if it comes to be more normal and common.

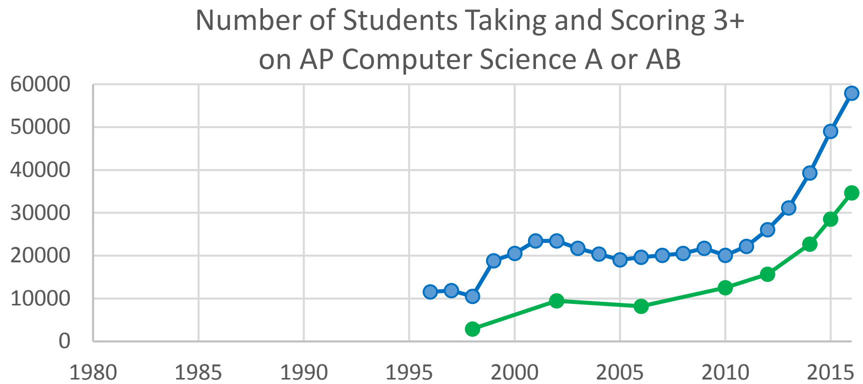
Recent efforts in high school computer science education

In the last several years Microsoft, Google and other tech firms have supported a number of efforts to bolster high school computer science education. This includes both out-of-school programs like Girls Who Code and Made with Code, which encourage girls to develop an interest in computer science, and within-school programs like the Microsoft's TEALS, which connects high schools with volunteers who support introductory or AP computer science classes and has expanded from 4 schools in 2010-2011 to 162 schools in 2015-2016.

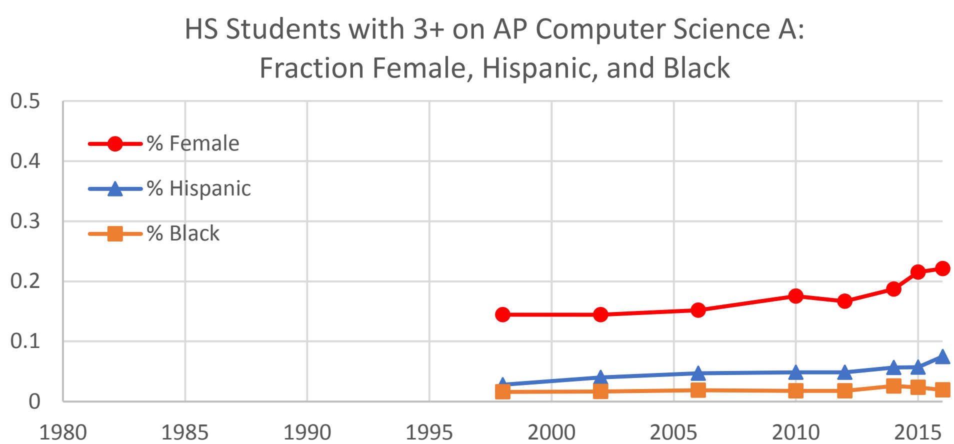
In some respects the last few years was a very favorable time for expanding AP Computer Science. Overall AP participation has continued to grow (46% more tests were taken in 2016 than in 2010), and in 2010 AP Computer Science participation seemed overdue for an increase – it had not grown at all between 2000 and 2010 whereas overall AP test-taking increased by 153% in that time. In other respects, however, there are substantial challenges to expanding the program. Many schools offer no computer science classes at all, so it is not just a matter of convincing schools to increase the level of their current classes. And many schools lack teachers with sufficient expertise to offer classes. Indeed, if one looks at schools that newly offer AP Computer Science the results are often quite poor. For example, 24 Massachusetts public schools appear to have offered AP Computer Science in 2016 after not having offered it in the previous year.[2] At the majority of these schools (14 of 24), the majority of students failed the exam. Hardly any students at these 14 schools did very well: only 12% earned scores of 4 or 5 on the exam.

[2] This counts all schools administering the test to 10 or more students in 2016 after having administered it to 5 or fewer schools in 2015.

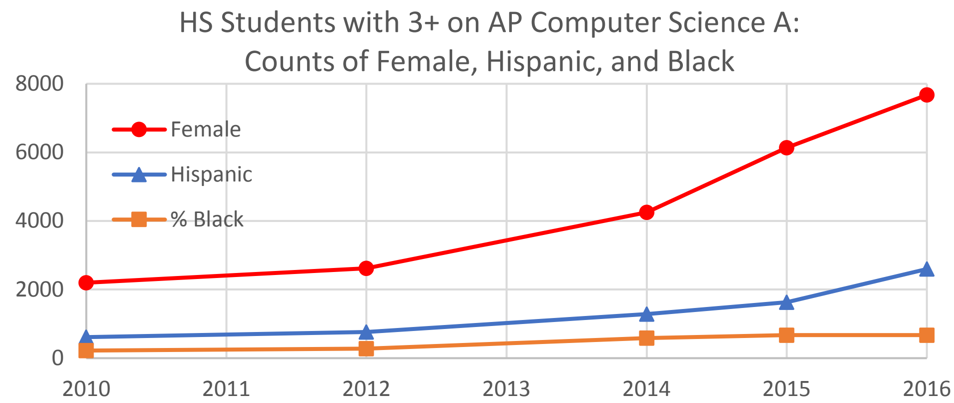
Finally, we come to some good news. The growth of AP Computer Science since 2010 has been a great success story. The number of students taking the exam has nearly tripled in just six years. The number of students with passing marks has grown nearly as fast.



The growth in AP Computer Science involves both growth in the number of participating schools and to growth in the number of students per school. As noted earlier, there is reason to think that increasing the within-school popularity would, by itself, narrow the gender gap. Whether for this reason or the various other efforts, the gender gap in AP Computer Science has narrowed: the percent female among students with passing marks has increased from 17.5% in 2010 to 22.1% in 2016. Hispanic representation has also increased from 4.9% in 2010 to 7.5% in 2016. The percentage black increased slightly, but then fell back to the 2010 level. Again, this may reflect the greater challenges of improving minority outcomes: many schools serving minority communities lack the physical and/or human resources needed to offer computer science courses; and we do not yet know how restrictions on affirmative action have affected or will affect access to magnet programs.



While the percentage increase numbers are not so striking, if one converts back to counts of the number of students from each group passing the test one gets a more encouraging view of progress: the number of black, Hispanic, and female students with passing marks on the AP Computer Science have each more than tripled in just six years. The 7,674 girls still pales in comparison with roughly 80,000 girls passing AP Biology, but it is much more encouraging than just 2,201. Minority counts remain very low in absolute terms.



Recap

In this article I've noted that the striking lack of success in diversifying the IT workforce follows an even more striking lack of success in diversifying university computer science programs. The loss of undergraduate women post-1985 really sets computer science apart from other STEM fields, and there have been only small improvements in minority representation. Diversifying the IT workforce will require a variety of efforts at the employment, retention, and advancement stages, but IT firms cannot restrict themselves just to what goes on in their firms. Some large effort to improve outcomes at the undergraduate level will clearly also be required.

One factor contributing to low female and minority representation at the college level is the disparity in advanced high school work. Here the challenges inherent in increasing female and minority representation are different. Computer science courses (let alone high-quality ones) are simply unavailable in the high schools that many minority students attend. Whereas increasing female participation is probably more a case of making computer science a normal part of any student's program – high school girls are doing very well in in many other areas where their success is expected.

In contrast to the many lack-of-success stories I have noted, the recent surge in AP Computer Science is an indication that the some progress is being made. The gains in diversity in advanced high school coursework are not yet very large in magnitude. And it will be a few years before we have a chance to see if they are followed by increases in the diversity of college programs. But the fact that concerted efforts have helped produce a large surge in participation, and the fact that the surge in participation has been accompanied by some progress in diversity is encouraging.

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