The Gender Disparity in Coding

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by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Preface

Computer science skills are well known to be in high demand. How can aspiring software engineers and their future employers best serve each other?

A missing component of many undergraduate computer science programs is that students are prepared for the workforce, but not its interviewing process. The students who learned what to expect in an interview, often outperform those who don't. My goal is to design an undergraduate course to teach how to translate students' undergraduate learnings to interviewing skills. I and many of my classmates wished this course existed during our undergraduate experience so far. I set out to research what skills are most tested in most software engineering interviews, and what is the most effective way to prepare students for it. In the end, my course design included a structured syllabus of what topics to teach week-by-week, as well as a sample homework assignment for one of the weeks to be used to base future assignments off of.

Data shows that women are underrepresented in computer science. Their underrepresentation has possibly led to companies' lack of innovations and bias in software. After seeking to learn what is being done about the problem and how productive it has been, I learned that different organizations have stepped up to enhance young females' education experience in computer science, build their confidence in their ability to code, pave paths to teach them coding, and find ways to attain and retain women coders in their institutions and/or jobs. Statistical data shows that the gender gap, although improving, is not closed yet. My findings show that the work being done by various organizations and tech companies has been successful, and more educational institutions and tech companies should follow in their lead to solve the problem.

The Gender Disparity in Coding

Career opportunities in computing have been growing, but women are less likely than men to enter this workforce, causing a gender gap. Between 2003 and 2013, the IT industry field grew by 37 percent in the USA (Csorny, 2013). Moreover, in the U.S., employment in computer science occupations is projected to grow 11 percent from 2019 to 2029,
faster than the average of all occupations (BLS, 2020). However, historical data suggests the female share of computer science bachelor's degrees peaked at 37 percent in 1984, before going into a steady decline that stabilized at about 18 percent in 2008 (Perry, 2018).

A study by Deloitte found that women's choices account for up to 85 percent of buying decisions nationwide, and used it as evidence to argue diversity drives innovation (Paul, 2001). The decline in women pursuing computer science has grown concerns of improving perspective in the field, workplace equality, and encouraging innovation. What is being done to close the gender gap and by who? To increase the share of women in computing careers, advocacies strive to offer girls more opportunities for education in computer science, and to build their confidence as coders. They then seek to improve retention and promote career development paths for young women computing professionals.

Review of Research

University of Washington researchers sought to find why some STEM fields are balanced while others are not. They reasoned that three factors explain the larger gender gaps. These are that a masculine culture can signal a lower sense of belonging to women, lack of sufficient early experience, and gender gaps in self-efficacy (Cheryan et al., 2017). Cheryan and her team present these three factors in the form of a model to explain the gender gap. Some of the these

factors are the backbone problem that various participants are focused on solving as part of the bigger mission to close the gender gap. It validates their entire existence by acknowledging that it their work can improve women participation in computer science. Beasley and Fischer (2012) studied the effects of performance anxiety on the attrition of women and minorities in STEM majors. They focused on the impact of stereotype threat, which they found minorities experience the most, and that stereotype threat does increase the likelihood of all people who experience it to leave STEM majors. Their study provides valuable perspective of the vulnerability of college students when studying computer science. It also evidences the importance of making schooling an encouraging environment to promote women in computer science. A similar study was done by University of Texas researchers who approached the gender gap problem by focusing on the students' view of scientists. With ~1000 Black and Latinx adolescent participants, their study focused on finding counter-stereotypical views of scientists and observing if those views impacted any subsequent intentions to pursue STEM. Their results found that having counter-stereotypical perceptions of scientists do promote youths' intention to pursue the STEM fields in which they are underrepresented. Female students, and especially black female students in particular, held the most counter-stereotypical views in their survey (Nguyen & Riegle-Crumb, 2021). Nguyen and Riegle Crumb's study confirm the importance of inspecting the gender gap problem from an early age in women, and provide valuable insight on how the gender gap problem in STEM can be related to the racial gap problem.

These survey results echo themes of low confidence, accessibility, and exposure to computer science that persisted throughout my research, and show how a gender gap and racial gap in computer science are tangentially related. They each target different groups for their study, specifically Black and Latinx adolescents in Nguyen and Riegle-Crumb's study,

undergraduate women STEM majors in Beasley and Fischer's study, and comparing some STEM fields to other STEM fields in Cheryan and her team's study.

Providing Extra Support in Computer Science Education

A widening gender gap starts at early schooling. Access to a computer science curriculum can be rare, and social constructs can deter females from STEM topics.

The Program for International Student Assessment (PISA) is an international assessment that, among other subjects, measures 15-year old students' mathematics literacy (NCES, 2018). In 2015, the average difference between high-achieving boys and girls was 19 PISA points, the equivalent of around half a year of school. However, when comparing boys and girls who reported similar levels of self-confidence and anxiety towards mathematics, the gender gap in performance disappeared. The study reasons that exposure to early gender biases can be one of the factors into why women can be deterred from STEM fields (OCED Insights, 2015). Various organizations have been founded based on similar concerns, and have built agendas of helping women into computer science education.

Career development is a lifelong process that involves constant growth and change. "Children actively explore their worlds and begin to construct possibilities for present and future selves" (Cahill & Furey). Through their experiences, children learn skills to fulfill educational, career, and personal tasks. A child's aspirations can change often and are influenced by many factors, such as family relationships, interests, and education. The previously mentioned study by PISA evidences this as different gender social constructs in different countries have led to more

women or male participation in certain careers, such as when deterring females from STEM careers (Cahill & Furey).

Studies by various universities and research organizations have confirmed the positive effects of early programming instruction. In 2002, researchers from Ohio State University taught a week-long computer science workshop to 28 eighth-grade girls. They hoped to introduce the aged 12-13 students to computer science and to dispel its negative stereotypes. Metaphors from cooking and other areas of experience were used to guide their learning. Participant evaluations at the end of the workshop indicated that the course they took was one in which they "learned the most about engineering." The study concluded that one way to pique girls' and boy's interest in computing disciplines would be to start earlier and can be done so using creative metaphors, such as cooking and music in their case (Demirbas, Sivilotti, 2003).

Despite evidence showing that the demand for computer science skills is growing fast, data compiled in 2020 in collaboration with Code.org, the Computer Science Teachers Association (CSTA), and the Expanding Computing Education Pathways (ECEP) Alliance, show that only 47 percent of American high schools teach computer science. However, female participation in the AP Computer Science exam has quadrupled since 2014, increasing from 22 percent to 29 percent of exams, showing a growth trend but still not total equality. The data also proves that computer science is not immune from the effects of social inequities and systemic racism. For example, of the female participants, 7.5 percent identified as black or African American despite making up 15 percent of the female student population. Income level and access to computer science are also disproportionate, as the data shows that access to computer science decreases in schools as the percentage of economically disadvantaged students increases.

These organizations are among the many that focus on closing the gender and racial gap within early computer science education (Code.Org et al., 2020).

Code.Org is a nonprofit "dedicated to expanding access to computer science in schools and increasing participation by young women and students from other underrepresented groups." Among other projects they have, the annual "Hour of Code" campaign is one they designed to show anybody they can learn the basics, and thus broaden participation in coding (Code.Org, 2019).

During the "Hour of Code," students around the world are introduced to computer science (or are encouraged to expand on their skills) by taking one hour to focus on coding. The event is celebrated during the Computer Science Education Week every year but can be self-started any time of the year. The campaign organizers believe that a low commitment of "one hour is only enough to learn that computer science is fun and creative." To make the event more accessible, Code.Org has created tutorials that work on PCs, smartphones, tablets, and some that require no computer at all. They've also created tutorials specifically for teachers to show them how to set up an hour of code event for their classrooms and for parents to get them started with their children (Hour of Code, 2020). Code.Org also has an extensive partnership network to increase the amount and variety of coding tutorials participants can get involved in. This includes Microsoft's Mojang Studios, creators of Minecraft, which created a tool for students to use basic coding concepts to follow along with a story within their game (Minecraft Education, 2021), and also Khan Academy, an online education platform, which has created multiple coding tutorials specifically for this event that can be done in about an hour (Khan Academy, 2021).

The inspiration for this campaign is because "every student should have the opportunity to learn computer science" (Code.Org, 2019). 45 percent of Code.Org's students are young

women, and they have been able to reach over 1 billion total participants worldwide in their "Hour of Code," 50 percent being female. This is an impressive improvement on the current 29 percent female participants in AP Computer Science. Since their launch in 2013, both overall participation and the overall proportion of women and other marginalized groups participating in the AP Computer Science exam have been increasing, indicating that progress is happening. Code.Org acknowledges that "improvements aren't the result of Code.Org's work alone… but the real credit belongs to the thousands of teachers who have worked for years to improve diversity in their classrooms" (Code.Org Diversity, 2020), which Code.Org is helping by providing tools for their teachers.

Supporting the education of young women has also proven to be important at the university level.

The BRAID initiative (Building, Recruiting, and Inclusion for Diversity), co-led by AnitaB.Org and Harvey Mudd College is a partnership within currently 15 undergraduate computer science departments that have committed to implementing a combination of four commitments in efforts to increase the participation of students from underrepresented groups. They "aim to increase the number of women and members of underrepresented minority groups in computer science departments." As part of the initiative, a UCLA research team is conducting a study observing departmental changes concerning the commitments across the "BRAID schools." The commitments include "modifying introductory CS courses to make them more appealing and less intimidating to underrepresented students," "leading outreach programs for high school teachers and students to build a diverse pipeline of students," "building confidence and community among underrepresented students," and "developing/promoting joint majors in

areas like CS and biology that are attractive to underrepresented students" (AnitaB.Org BRAID, 2021).

BRAID schools begin by gathering demographic statistics on undergraduates in their department and use them to identify any trends during the past five to ten years. Once the data is reviewed, the department faculty and students work together to develop a diversity statement that outlines clear goals. BRAID outlines specific recommended tactics to include in participating schools' diversity statements. This includes reaching out to the K-12 community in local schools to get students interested early in their academic careers. Activities include programs such as after-school events, summer camps to teach computing and even teaching an introductory computer science course to local high school teachers and training the educators on how to adapt content for their students. BRAID points out to be intentional about recruiting girls and members of underrepresented minority groups to participate (AnitaB.Org Braid Activities, 2020).

BRAID further encourages participating schools to enhance the computer science experience at their department by making courses seem less intimidating to students with no experience. This includes offering introductory computer science courses separately for novice students and experienced students, which allows students in each section to be more comfortable asking questions, while still covering the same fundamental principles. It also allows for non-CS majors to easily gain exposure to computer science. Furthermore, recruiting diverse faculty and TAs to teach introductory computer science courses, while selecting individuals who enjoy teaching and are effective. BRAID encourages including hands-on projects in computing courses to emphasize practical applications. Lastly, BRAID encourages undergraduate computer science departments to reach out to a wider range of students by partnering with other departments to develop interdisciplinary courses and joint majors (AnitaB.Org Braid Activities, 2020).

A final thing BRAID recommends is to build a safe and supportive environment for students. This can be done by launching student computing clubs that specifically allow women and members of underrepresented minority groups to work together, share recourses, and develop community. The groups should involve faculty in a variety of programs, such as speaker events, hackathons, mentorship, and sending groups to conferences and events (AnitaB.Org Braid Activities, 2020). BRAID even outlines which events they recommend, such as the Grace Hopper Celebration, an event hosted by BRAID affiliate AnitaB.Org which is also the world's largest gathering of women technologists, with 30,000 annual attendees (AnitaB.Org GHC, 2021).

BRAID institutions' results have paid off. There has been an 87 percent increase in overall computing enrollment growth from 14,999 in 2015 to 28,072 in 2019. Additionally, 139 percent increase in women enrolling students, from 2,293 in 2015 to 5,480 in 2019, and a 106 percent increase in Black, Latinx, and Indigenous (BLI) students and 127 percent for Black, Latinx, and Indigenous women students. Specifically, along with the four commitments from BRAID schools, there were consistently high reporting of success in the commitments, such as 100 percent of the schools were able to offer student groups for women and/or underrepresented minority students and 93 percent did some kind of outreach to increase diversity in their computing major (BRAID, 2020).

The University of Washington, one of the "BRAID schools," has been recognized by the National Center for Women and Information Technology for its success in promoting women in computer science. In 2005, 15 percent of UW computer science bachelor's degree recipients were women. The number rose to 30 percent in 2015 when UW was recognized by the NCWIT. UW computer science professor Ed Lazowska stated, "although our 30 percent still leaves us

with a long way to go, we've worked really hard over many years, and I'm truly thrilled to have it recognized" (Romano, 2015). The 2020 enrollment data from UW showed a 33 percent female enrollment rate in their computing program (University of Washington, 2020).

Harvey Mudd College, although a smaller university than UW with 172 conferred bachelor's of science degrees in 2018, is another successful "BRAID school." That year, 56 percent of computer science majors were women (Harvey Mudd College, 2018). Harvey Mudd's president since 2006, Maria Clawe, attributes the university's successful diversity efforts to creating an environment that was supportive and engaging, building confidence and community among underrepresented groups, and demystifying the path to success. This included taking steps that BRAID has outlined, such as making different levels of introductory courses and making classroom assignments collaborative and with practical assignments (Weisul, 2017).

The Tech Companies Efforts

Well-known tech companies have acknowledged the problem and created agendas to increase their female workforce. They've started to become more transparent about their diversity by publishing annual diversity reports, which help show the public whether they are reaching their diversity goals. When comparing one year's report to a previous year, that company can observe if its efforts have been effective.

Google claims it values diversity: "by building a workforce that is more representative of our users and a workplace that creates a sense of belonging for everyone, we are building a better Google—together." In Google's annual diversity report, the percentage of women on Google's U.S. staff increased from 29 percent in 2014 to 31.6 percent in 2020. For tech roles specifically,

the percentage increased from 17.4 percent to 24.7 percent. Moreover, in 2020, an impressive 40 percent of global interns in tech roles were women (Google Diversity, 2020).

Many of Google's programs to support their mission focus on increasing the diversity of their hiring pool by providing support to computer science education from primary school through university. For college students, this is in the form of an internship program that only considers applications from females and other underrepresented groups, the "BOLD Internship Program" (Google, 2020). Another program is "CS First," a free computer science curriculum that provides teachers with the tools and resources to teach basic computer science. This aims to expose more students to computer science at an early age and give them confidence that it is a career option for them. They claim to have 10 million lessons taught since 2014 (Google For Education, 2020). Similar programs that target specifically the underrepresented minorities in their workforce are Tech Exchange, a university-student exchange program where Google hosts courses for attendees at their offices, and Code Next, a workshop style program that pairs high school students with Google mentors (Code Next, 2020; Madda, 2019). Google is just one company of the many in the tech industry that is struggling with diversity and trying to close its gender gap. Other tech companies have also started introducing similar diversity-focused programs, such as Facebook, which also has a diversity internship program: Facebook University (Facebook, 2020).

Along with the programs to bring more women and diversity into their workforce, companies have also begun shifting their workplace culture and benefits to increase the retention of their existing underrepresented groups. For example, Facebook allows employees six weeks of paid leave to care for sick children and family members, which especially benefits women because they are often the ones who take on this role. Various large tech companies also offer

excellent maternity benefits, such as paid and extended maternity leave, and family forming benefits, through support infertility, surrogacy, and adoption processes (ComputerScience.Org, 2020; Ro, 2019).

Conclusion

Historical demographic data has shown that increasingly fewer women are participating in computer science. The growing problem sparked many organizations to focus on increasing women participation in the ways that they can. This includes organizations focused on aiding females' path to learn computer science and tech companies creating missions to hire and retain more women for their software roles.

Though these efforts have proven to work, the mission is not yet complete. The organizations, universities, and tech companies involved in creating more female computer scientists should lead as an example for others. More and more educational institutions and companies need to learn how they can offer their help in the problem. As they do, the gender gap will continue to close at a faster rate.

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