The culture must change to encourage women throughout their education to pursue computer science and engineering and to welcome and support female technology workers in industry, academia, and government.

Computer innovation is at the heart of major advances in sectors such as scientific research, healthcare, education, and consumer products. To achieve breakthroughs, computer engineers and scientists must be willing to approach a difficult technical problem from various perspectives. Indeed, research shows that for cutting-edge innovation, group diversity along multiple dimensions is more important than the individual ability of group members.

Realizing the benefits of group diversity, however, is contingent on a supportive culture that encourages and leverages different views. Unfortunately, the shrinking pipeline of technical women threatens to inhibit progress in computing and computer engineering. We discuss the lost opportunities for innovation caused by a dearth of women in the industry, examine the causes of this underrepresentation, and discuss programs and practices that aim to change these trends.

THE PIPELINE CHALLENGE

Research clearly demonstrates that gender diversity greatly enhances innovation, decision making, profits, and shareholder value in the computing industry. However, there is a significant shortage of women at all stages of the pipeline, along with several barriers to retaining and advancing those women who do enter the field.

Even as the global demand for computing talent is surging, women's representation in the profession has steadily declined. The proportion of females in the US earning computer science undergraduate degrees plummeted from a high of 37 percent in 1985 to 18 percent in 2009. At research-intensive institutions, the proportion of women earning CS bachelor's degrees dropped from 19 percent in 2000-2001 to 11.7 percent in 2010-2011. For women from underrepresented minority groups, the disparity is even more acute: African-American women earn only 4 percent of CS bachelor's degrees and Latina women less than 2 percent, figures that have remained flat since 1985. Women's participation in advanced computer science education is only slightly better: the percentage of females earning CS master's degrees fell from 34 percent in 2000 to 27 percent in 2009, while the share of women earning doctoral degrees has held steady at 22 percent.

The problem extends well beyond the US. The combined representation of women with CS and mathematics undergraduate degrees is 35 percent in Germany, 26 percent in the UK, 24 percent in France, 25 percent in Spain, 23
Only 25 percent of computer scientists are women, and their representation in the technology industry follows a pyramidal structure, with progressively fewer toward the top.

Persistent, unconscious bias. Women who do enter computing careers are likely to continue to experience persistent, unconscious bias, hindering their retention and advancement. Research shows that people associate technical and leadership competence with male traits, resulting in implicit favorable bias toward men in the technology industry. Female engineers report being sidelined from the innovation process, and condescending or unfair treatment is a key cause of turnover among women in scientific professions.

Discouraging cultures. Technological professions typically favor assertive communication styles, reward competitive behavior and self-promotion, and embrace “hero” cultures associated with stereotypically male work traits. This puts women in a double bind—they are told to be more assertive but are labeled “aggressive” if they follow cultural norms.

Many tech companies also fail to acknowledge their employees’ family responsibilities and predicate promotion on having a stay-at-home partner and being available 24/7. This further discourages female advancement, as women in the computing industry are twice as likely to have a spouse who works. Indeed, research indicates that 79 percent of female technologists have a partner who works full time, compared to 38 percent of men.

OFFERING SOLUTIONS: THE ANITA BORG INSTITUTE

Experience shows that gender diversity will not increase unless these barriers are overcome. Individual women must be aware of stereotypes and unconscious bias; demonstrate leadership; recruit, mentor, refer, and sponsor female colleagues; and demand more equitable new-hire selection panels. At the same time, companies must set real goals for gender diversity and hold leaders and managers accountable for progress. However, breaking down cultural and institutional resistance is difficult, and many organizations have emerged to help effect change.
The Anita Borg Institute (www.anitaborg.org) is a not-for-profit 501(c)(3) charitable organization dedicated to increasing the worldwide participation of women in computing and engineering. Founded in 1997 by computer scientist Anita Borg, ABI works with industry, academia, and government to recruit, retain, and advance female technologists. It also fosters community and provides resources and tools to help women develop their technology careers.

ABI reaches more than 17,000 individuals every year through its face-to-face and online outreach efforts, while its communities connect more than 60,000 people. ABI programs and initiatives have brought about real change in companies that care about moving the needle for women and have raised awareness about the benefits of gender diversity in terms of both innovation and market share in the technology industry overall.

**Programs for individuals**

ABI’s programs directly address the challenges technical women face at every stage of the pipeline. The programs are grounded in research, designed to raise awareness about stereotypes and unconscious bias, and provide the technical knowledge and career advancement skills that enable women to fully realize their potential in the workplace.

**Grace Hopper Celebration of Women in Computing.** Established in 1994, GHC (www.gracehopper.org) is the largest gathering of technical women in the world. In the past five years alone, this signature ABI program has served more than 11,600 attendees from more than 40 countries. About 40 percent of participants are college students, with the remainder consisting of women from industry, academia, and government at all stages of their careers as well as male advocates. The hundreds of conference leaders, committee members, scholarship applicant reviewers, and speakers are all volunteers from a global community committed to giving technical women who feel isolated more opportunities to engage in a rich and supportive network.

Designed specifically to address gender-based barriers to a computing career, GHC program content includes:

- keynote speakers such as Sheryl Sandberg, Facebook’s COO and first female board member, and Maria Klawe, president of Harvey Mudd College, who inspire, encourage, and model leadership;
- invited speakers and sessions that explore developments within the field of computing and highlight technical career options;
- professional development sessions that equip women with skills to advance their careers;
- a Senior Women’s Summit designed to help senior women advance and network;
- a Career Fair that provides a dynamic marketplace and resume database for recruiters and job seekers, attended by more than 100 companies and universities interested in recruiting technical women;
- poster sessions where more than 200 female technologists present their research, constituting the largest source of submissions to the ACM Student Research Competition;
- awards that honor individuals and teams from around the world for significant contributions to the advancement of women in technology through leadership, social impact, education, and advocacy in their communities;
- opportunities to help attendees extend their personal networks and make mentoring connections; and
- Open Source Day, where women collaborate on software development projects that benefit society.

Sponsorship by the National Science Foundation, industry, and academia enables approximately 300 female students to attend GHC each year on scholarship. Participation at the conference is a unique catalyst for students on multiple levels—they connect with peers, meet industry leaders and faculty, see role models, and learn about careers in computing. The sidebar “The Power of Mentoring Connections” provides an example of one student whose life was changed by GHC.

ABI’s evaluation of all attendees and an NSF-funded three-year, longitudinal study of scholarship recipients demonstrated that GHC motivates female students to choose computing as a major and inspires them to enter and then remain in technical careers:

- nearly all GHC scholars were still engaged in STEM fields 20 months after attending the conference;
- GHC scholars learned about career and academic opportunities in technical fields and acquired tools to build a successful career;
- about one in five GHC scholars reported receiving a job offer through the conference.
- GHC Scholars reported feeling energized and confident about a technical career long after exposure to the conference environment;
- 20 months later, 40 percent of GHC scholars stayed connected with industry professionals and faculty whom they met at the conference; and
• 61 percent of GHC scholars mentored others in their field, and 49 percent reached out to high schools to encourage more girls to pursue a computing career.

Grace Hopper India. In 2010, ABI brought the benefits of the GHC program to India, establishing the yearly GHCI conference in Bangalore (http://gracehopper.org.in) to address global barriers to gender diversity, especially those unique to India. In developing countries like India, where often there are deep-seated perceptions that a woman’s main responsibility is to her family, technical women generally face more resistance than in western countries. GHCI has served nearly 2,700 women, mostly from India, during the past three years.

Grace Hopper Regional Consortium. Led by the ACM Committee on Women in Computing (ACM-W) in collaboration with ABI and the National Center for Women & Information Technology (NCWIT), GHRC (http://ghregionalconsortium.org) supports one- and two-day regionally focused conferences modeled after GHC. Faculty from CS university programs in a designated region organize 10 to 12 events per year, each attended by 100 to 150 local students. These conferences provide intimate settings to strengthen local communities of technical women, connect them with mentors, and encourage their participation in computing careers.

ABI Women of Vision Awards. Each year, some 800 women and men gather to honor three women who have made major contributions in the areas of technical leadership, innovation, and social impact. This inspirational event showcases the personal stories of accomplished female role models and provides networking opportunities for attendees.

Systers and other ABI communities. ABI fosters communities designed to decrease isolation and increase access to social networks. Established in 1987, Systers is the oldest and largest online community of female technologists. It provides a safe and confidential environment where more than 4,000 women with like interests discuss sensitive challenges they face, engage in technical and career discussions, and help each other learn new skills. ABI also offers numerous social media tools to cultivate additional networks and connect them to news and resources that engage more than 60,000 individuals in more than 180 countries.

Initiatives to change the culture

Helping individual women to succeed is critical but will not alone bring about gender diversity in the computing industry. At a time when organizations are hungry for highly trained technical talent, an increasing number of leaders are recognizing the importance of changing their institutional culture and are taking active steps to recruit, retain, and advance skilled female technologists. ABI has developed several initiatives to further these goals.

The Power of Mentoring Connections

Sarah Loos, a doctoral candidate in computer science at Carnegie Mellon University, shared the following story about how participating in a Grace Hopper regional computing conference changed her career trajectory:

I first met Fran Allen in 2007, when I was 19 years old and just starting my junior year of undergrad studies. Fran gave a keynote talk at a conference on research in CS, then she hung around to hear a few of the undergraduate presentations, including mine on my improved version of the Strassen-Winograd algorithm for matrix multiplication. After the session, she came up to me and told me that my research was interesting and that she would have to tell Shmuel about it when she got back to IBM. I had to ask who Shmuel was—and Fran said his full name: Shmuel Winograd. Coming from a math background where all the famous names—Lagrange, Gauss, Euler, Fermat, etc.—have been dead for centuries, I was actually shocked to find that Winograd was still doing research at IBM, and I couldn’t even process the fact that he was going to hear about my summer research project.

In 2006, Frances Allen became the first woman to receive a Turing Award, the highest honor in computer science. The value for a young female colleague to meet someone like Fran Allen, much less have her work connected with another role model at the top of his field, is incalculable. Fran kept in touch with Sarah at subsequent conferences and advocated for her to join the ABI Board of Trustees as its first student member.

Sarah stated, “What the Grace Hopper Celebration and other ABI programs have done for me is to provide a community where these kinds of relationships can form…. Having encouragement from mentors who know you helps to even the playing field.”

ABI research. ABI translates findings from the best academic studies into practical, actionable solutions. For example, the seminal report “Climbing the Technical Ladder: Obstacles and Solutions for Mid-Level Women in Technology,” by researchers at ABI and Stanford University’s Michelle R. Clayman Institute for Gender Research, is the only large-scale study to focus on gender diversity in the tech industry. ABI also documents emerging best practices and makes recommendations that individuals, managers, and organization leaders can implement to bring about change in the workplace.

Anita Borg Top Company for Technical Women Award. Assessing successful change requires metrics and accountability, and this annual award recognizes an organization that has demonstrated measurable improvement in the representation and advancement of technical women at all workforce levels based on rigorously developed industry and peer data. The inaugural winner was IBM in 2011, followed by American Express in 2012 and Intel in 2013. The award recipient, along with other companies that have committed to gender diversity, are featured at a workshop...
Recruiting and Retaining Technical Women

Many top companies have made serious efforts to recruit and retain technical women. The following are among many examples documented in Solutions to Recruit Women (C. Simard and D.L. Gammal, Anita Borg Institute, 2012).

Retention programs increase recruitment

In recent years, Intel has invested significantly in work-life programs to enhance retention and recruitment of women beyond the entry level.

Key elements of these programs include

- a paid eight-week sabbatical program for US and Canadian employees for every seven years of service;
- compressed work weeks, part-time work options, and telecommuting privileges;
- family support such as homework help and tutoring for children of Intel employees; and
- paid parental leave and a “new parent reintegration program” allowing for gradual return to full-time work.

Outcome: Between 2004 and 2010, Intel increased its representation of mid- and senior-level technical women by 24 percent.

Companies can leverage networks

IBM has made internal networks a cornerstone of its diversity recruitment. The company actively encourages technical women to refer female colleagues for employment at IBM.

Key elements include

- leveraging employee networks to make recruitment more personal;
- providing incentives such as bonuses to encourage referrals of diversity candidates—the amount of the incentive varies by country;
- offering a strong infrastructure to support technical women within the organization, making existing employees more likely to refer others for employment; and
- closely monitoring referral success rates.

Outcome: IBM estimates that it hires close to 30 percent of its professional women worldwide through these connections.

One manager can change mind-sets

Regardless of whether a company has a formal policy on diversity, individual leaders can have a significant impact by making the hiring of qualified women a priority. When an engineering executive at Intuit needed to grow her team in India, which was initially all male, she pushed to represent women in numbers comparable to those of the broader Intuit engineering community—a significant increase from the typical percentage on teams in India.

Key elements include

- securing an executive commitment to ensure that the pool of candidates has a fair representation of women;
- setting goals to guide managers;
- educating managers about the value of hiring diverse teams; and
- extending recruitment efforts to attract qualified female candidates.

Outcome: Through this one leader’s commitment to change, the percentage of women in the group increased from 0 to 20 percent in six months.

where company leaders and managers gather to share their experiences and ideas.

The Technical Executive Forum. This invitation-only program convenes technology executives in a confidential and private setting to engage in frank discussion, exchange best practices, and build a community of technical leaders who are working to make their corporate cultures more welcoming to women. Each year, leaders of more than 40 companies gather to hear about new research, learn from peers, and advocate change.

ABI partnerships. ABI works with more than 200 companies and government institutions to bring about gender diversity and help technical women advance in their careers including partners Google, Microsoft, Hewlett-Packard, Cisco, Thomson Reuters, Amazon, CA Technologies, Dell, eBay, Facebook, IBM, Intel, Intuit, Juniper Networks, Lockheed Martin, Marvell, the National Science Foundation, the National Security Agency, NetApp, SAP, Symantec, Broadcom, EMC, Neustar, Raytheon, Salesforce.com, VentureLoop, Xerox, and Yahoo.

These organizations develop transparent technical tracks, demand diverse candidate slates for open positions, build training and supportive networks to address gender-specific barriers, and set explicit internal or public goals to increase women’s representation at all levels. The “Recruiting and Retaining Technical Women” sidebar provides some examples.

WHAT CAN YOU DO?

Broadening participation in computing will spur innovation and produce technological solutions that improve our world as well as a company’s bottom line. Despite more than a decade of efforts by ABI and other like organizations, however, gender-based barriers in the industry persist.
Comparatively few women choose computing careers, and those who do leave the field at higher rates than men.

The culture must change to encourage women to pursue computer science and engineering throughout their education and to welcome and support female technology workers in industry, academia, and government. To create a tipping point, leaders in companies committed to gender diversity must take action on a large scale.

Some solutions are relatively resource intensive, such as modifying hiring and promotion processes or developing formal programs. Other solutions, however, can be implemented easily by individuals willing to take action.

If you are a technical woman or man:

- Be your own advocate—proactively seek mentors and sponsors, network with your peers, and find opportunities to demonstrate leadership or seek promotion.
- Advocate for technical women—refer them in your network for promotions or open positions and serve on interview committees.
- Be a mentor, sponsor, and role model for technical women —this does not require a formal program, and you will gain as much as or more than those you work with.

If you are a manager:

- Ensure that every slate for promotion or open position includes a qualified technical woman.
- Mentor and sponsor high-potential technical women, giving them opportunities to lead within your team or business.
- Encourage a flexible, welcoming workplace culture and develop “gender intelligence” to mitigate unconscious biases in your team.

If you are a company executive committed to organizational change:

- Know your data on representation and promotions and hold your managers accountable for resolving pain points in recruiting, retention, and advancement.
- Address barriers by developing employee resource groups, mentoring programs, flexible practices, and transparent technical career tracks.
- Model diversity from the top by advancing technical women to your executive team and board.

Reducing leaks at every stage in the pipeline is critical to meet the rising demand for skilled technologists and to ensure that all perspectives help shape innovation. Regardless of your gender or position, get involved with organizations like ABI, NCWIT, ACM-W, IEEE Women in Engineering (WIE), the Computer Research Association’s Committee on the Status of Women in Computing Research (CRA-W), and the Society of Women Engineers (SWE) to access resources and talent that can help you and your organization change the culture of computing to welcome women and meet the demands of our industry’s future.

References

**Cover Feature**

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In Brazil, researchers have been working together to increase our understanding of tropical ecosystems, human impact on the environment, biogenetics, and biodiversity. These efforts are providing new opportunities to improve our capabilities in data-intensive research and strengthen the eScience research community. From May 13 to 15, 2013, we will host a special eScience Workshop in the city of São Paulo, Brazil. The event will bring together more than 150 participants, including students and researchers from all over the world, to explore collaboration and research opportunities in areas such as environmental sciences, bioenergy, biodiversity, health and digital humanities. More information about the workshop and the registration can be found at the workshop website.

http://www.fapesp.br/eventos/latam2013

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