Addressing Core Equity Issues in K-12 Computer Science Education: Identifying Barriers and Sharing Strategies

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Women and underrepresented minority students continue to remain critically absent from computing. While many efforts exist to reverse the trend, too few focus on the place where a majority of children in the United States are educated—the formal K-12 (kindergarten to twelfth grade) secondary and post-secondary educational system. The pattern of underrepresentation begins at the K-12 level and K-12 computer science teachers are often the first responders in increasing the proportion of women and underrepresented minorities in computing. Sadly, the first responders themselves suffer from isolation, a lack of resources, no consistent certification requirements, and a lack of access to the significant cross-sector partnerships that would increase their capacity.

In order to address these needs, the Computer Science Teachers Association (CSTA), the Anita Borg Institute for Women and Technology (ABI), and the University of Arizona (UA) joined forces in 2009 to design and implement a Town Hall meeting and workshop for computer science teachers. This workshop was held at the Grace Hopper Celebration of Women in Computing (GHC), a well-established conference where industry, academia, and government meet to strengthen professional networks, the visibility of women in computing, provide professional and technical development, and participate in a national (and increasingly global) dialogue on equity in computing.

The response to the workshop proved extraordinary: the conference organizers received a total of 650 applications from teachers who wished to participate. Funding from the National Science Foundation, Google, IBM, and the Motorola Foundation enabled 97 participants to receive full scholarships to attend the workshop. The committee selected participants on the basis of their application, perspectives on equity issues, and proportion of underrepresented students in their schools.

1. The Town Hall: Barriers and Solutions for K-12 Computer Science Equity

The committee planned the Town Hall event as a way to engage the broader community represented at GHC in exploring K-12 computer science educators' equity challenges. The 212 participants who attended the Town Hall included K-12 educators, college and university educators, nonprofit representatives, and industry representatives. The discussion was broad-ranging, covering both in-school and out-of-school realities and all of the systemic challenges present in the education system. One of the key takeaways was that the digital divide is alive, well, and continues to impact students' lives at school and at home. Teachers highlighted several barriers to equity:

- *A lack of access and exposure to information technology* for underrepresented students who tend to come from poor communities.
- *A lack of teacher capacity*. While the participants in the workshop identified themselves as computer science or computing teachers, many of them teach multiple disciplines and are teaching computer science without infrastructure or curriculum resources from their schools.
- *A lack of student interest*. Participants noted that igniting student interest in computer science, especially in the case of girls and underrepresented minority students, is a significant equity challenge. Teachers agreed that looking in-depth at their pedagogy and asking whether their curriculum is truly engaging and inclusive for a diverse set of students is an important activity for them to undertake on an ongoing basis.
- *A lack of awareness from colleagues on the role of computer science (CS) in K-12 education*. One of the biggest challenges Town Hall participating teachers discussed is a lack of awareness and support from their own colleagues, often resulting in a debilitating dearth of resources.
- *A lack of school focus on the importance of CS*. The fact that computer science is not a "core course" is a critical barrier for teachers.
- *A lack of a coherent certification process for CS teachers*. Teachers expressed the conviction that advocacy is critical to addressing the current problems with teacher certification requirements.

Solutions to Barriers

The Town Hall discussion surfaced several solutions to these barriers:

1) An unrelenting focus to dispel myths and recruit diverse students to CS

Teachers believe that an ongoing focus on recruiting students and dispelling the myths and misconceptions about computer science as a discipline or a future career is absolutely critical for addressing computer science education pipeline issues and improving the participation of underrepresented student minorities. The teachers evidenced a deep wealth of ideas and experiences for recruiting students and used the Town Hall as a platform for sharing their strategies. For many participants, this would involve engaging in their own "image campaign" within their school and spending considerable time outside the classroom talking to prospective students.

2) Partnerships with other teachers

Teachers extensively discussed working in partnership with other teachers. Remarking that most students who excel in computer science start out by excelling at math, some teachers target their recruiting efforts at the math classes offered at their school, enlisting the support of their colleagues teaching math. Others, however, noted that it is important to think outside of our traditional perspectives and to focus more on engaging students who are passionate about the arts and humanities.

3) Partnerships across sectors

Strong partnerships with industry and academia can serve as an accelerator for systemic change, but for many teachers these partnerships remain illusive. A consensus emerged that there are far too few partnerships happening across sectors to boost K-12 computer science education. The network connections between public education, faculty, and industry are not well established. By and large, teachers, faculty, and industry participants reported few opportunities to interact before coming to the Town Hall.

2. The Equity Workshop

Teachers continued these discussions on day two of the event: the equity workshop. The purpose of the equity workshop was to provide teachers with relevant, practical, and professional development—and to provide opportunities for K-12 teachers to share strategies and best practices for overcoming acknowledged barriers to equity.

The workshop consisted of two general sessions attended by all workshop attendees and five presentations grouped into two breakout sessions. Dr. Jane Margolis, the author of *Stuck in the Shallow End: Race, Education, and Computing (2008)*, delivered the opening general session. Topics for the breakout sessions were wide-ranging, including presentations and discussions on engaging activities to embed computational thinking concepts across the curriculum; upcoming changes to the Advanced Placement Computer Science (APCS) program; how to teach computer science concepts using toys and manipulatives; and strategies for recruiting more students to computer science courses.

The final general session of the workshop consisted of a panel exploring culturally relevant tools for computing. The workshop concluded with Dr. Margolis facilitating a final wrap-up.

On-site and follow-up evaluations conducted with the participants showed that 91.7% of the responding teachers had implemented tools or resources they gleaned from the workshop and 80.6% had implemented useful strategies they gained from the equity workshop for engaging diverse students. The teachers also indicated they had used a variety of strategies discussed at the workshop and made changes to their curricula, including: reaching out to girls, creating opportunities for success, making assignments "relevant" to students, and incorporating collaboration.

3. A Model for Systemic Change

Too often, when discussing educational reform, a top-down approach is the norm, with both private and government policy experts pushing change onto K-12 educators without engaging them in the design of the change model. As a result, efforts to implement systemic and sustained change prove ineffective. We propose a model of cross-sector information and strategy sharing where the teachers are not just equal partners in the design and implementation of change initiatives, but are the acknowledged experts on effective change strategies for their classrooms. Furthermore, this model would provide all stakeholders a key role in the formulation, dissemination, and ongoing support of these successful strategies and best practices.

- *Academia.* Academic institutions have a critical opportunity to engage K-12 CS teachers in addressing key equity issues in computer science education. Universities have access to the latest developments in computer science. Post-secondary faculty are uniquely suited to provide K-12 educators with information regarding how K-12 can best prepare a diverse set of students to succeed in computer science at the college level. Post-secondary faculty and departments also have a responsibility to mentor and support K-12 teachers in their efforts to implement the changes necessary to ensure preparedness of a greater proportion of girls and underrepresented minorities. In addition, academia can work to better inform educational policy makers about the importance of providing all students access to rigorous computer science courses in high school.
- *Industry.* The private sector, and in particular the high-technology industry, has expressed concern about the incoming pipeline of diverse technical talent. While the financial and technology resources of industry can play an essential role in supporting K-12 CS teacher needs, our model places an emphasis on going beyond financial support and includes the provision of software to involve active knowledge exchange and participation. Industry representatives can engage with K-12 teachers to provide an accurate and up-to-date picture of the computational thinking skills that a diverse body of students needs to engage successfully in the workforce. Industry representatives can also provide critical support for the argument that success in today's global knowledge economy requires high-level analytical and collaboration skills and the ability to manage complex information. Industry has the opportunity to engage directly in the classroom by providing role models and mentors who can dispel the stereotypical beliefs that students, parents, and school administrators hold about a technology career. Finally, industry can play a major role in advocating with educational policy makers to ensure that every student has access to a rigorous computer science course in high school.
- *K-12 Teachers.* Teachers desperately need resources and support to increase equity in their classrooms. They have packed schedules, limited funds, professional development, and networking opportunities. This situation makes outreach across sectors inherently difficult. Access to events such as the Hopper Town Hall and K–12 Equity Workshop provide a key mechanism for illuminating the barriers and sharing the solutions among key stakeholders. Computer science teachers are at the front line of computer science education, struggling to achieve exemplary results often with exceedingly minimal resources and support. They know their classrooms and their students and can provide critical feedback to academia and industry on how best to use the available resources to achieve the greatest educational results. Teachers are critical actors in disseminating successful models of partnerships and solutions within their communities. Finally, industry and academia can benefit tremendously from working directly with the teachers and students, collecting precious information about the incoming generation of students and adapting their practices to create inclusive environments for the next generation of women and minority computer science students and workers.

This report describes the outcomes of this initiative, most specifically the barriers and solutions to equity in K-12 computer science education. Teachers, industry representatives, faculty, and policy makers can use this information to increase awareness of the issues facing K-12 education and engage in cross-sector partnerships to provide solutions.

1.0 The Intellectual Importance of Computer Science Education

Our world and every interaction within it are now inextricably linked with computing technology. Therefore, the ability to understand the complexities of controlling and creating this technology is fundamental to every educated person. Computer systems and the people who maintain them keep us safe on the road and in the air, help physicians diagnose and treat health care problems, and play a critical role in the design of new drug therapies. An engineer using a computer to design a bridge must understand how the maximum capacity estimates were calculated and their reliability. An educated citizen using a voting machine or bidding in an eBay auction should have a basic understanding of the underlying algorithms of such conveniences, as well as the security and privacy issues that arise when information is transmitted and stored digitally. Computer science knowledge is a critical twenty-first century skill, providing problem solving and critical thinking skills to all students, regardless of their eventual career path.

A fundamental understanding of computer science enables students to be, not just educated users of technology, but the innovators capable of using computers to improve the quality of life for everyone. The vast majority of careers in the United States requires an understanding of computer science. Professionals in every discipline—from art and entertainment, to communications and health care, to modern factory workers, small business owners, and retail store staff—need to understand computing to be globally competitive in their fields. While not all students will become computer scientists, all of them will interact in some way with computers and all can benefit from the knowledge and skills that computer science education provides.

Computer science education is strongly based upon the higher tiers of Bloom's cognitive taxonomy (Bloom et al., 1956), as it involves design, creativity, problem solving, analyzing a variety of possible solutions to a problem, collaboration, and presentation skills. Through studying computer science, students develop and extend logical thinking and problem-solving skills. Students can then apply these skills to real-world problems—mathematical and otherwise. Further, students with previous technology experience who take on high school computing classes demonstrate improved readiness for post-secondary studies.

Computer science students learn logical reasoning, algorithmic thinking, creative problem solving techniques—concepts and skills that are valuable well beyond the computer science classroom. For example, students gain awareness of the resources required to implement and deploy a solution and how to deal with real-world constraints. Skills students glean in computer science courses are applicable in many contexts, from science and engineering to the humanities and business, and have already led to deeper understanding in many areas. Computer science also teaches students to think about the problem-solving process itself. Once the problem is well defined, an algorithmic solution must be created: Students must select or build computer hardware and peripheral devices, design algorithms, as well as write and test computer programs that work with this hardware and software. A computer scientist is concerned with robust, user-friendly, and maintainable computer solutions that solve business, scientific, and engineering problems.

Progress in science has always been linked to progress in technology and vice versa. Solving the pressing problems of the twenty-first century—such as grappling with new diseases and climate change—demands people with diverse skills, abilities, and perspectives. Most especially, solving these pressing problems requires people who can integrate computing knowledge with other discipline-specific knowledge. For example, the use of modeling and simulation as well as visualization and management of massive data sets has created an entirely new field: computational science. This field blends such aspects of computer science as algorithm design and graphic design. In science classes, students may use sophisticated simulation software to make molecules and geological processes come to life. Writing computer programs that model behavior allows scientists to generate results and test theories that are impossible in the physical world. Advances in weather prediction, for example, are largely due to better computer modeling and simulation. Computational methods have also transformed fields like statistics and mathematics. Therefore, studying computer science provides a solid basis for exploring or creating innovation across a multitude of fields and provides skills that will serve a student throughout his or her lifetime.

We consider it critical that students are able to read, write, and understand the fundamentals of mathematics, biology, chemistry, and physics. But to be a well-educated citizen in today's computing-intensive world, students must also have a basic (and ideally a deeper) understanding of the fundamentals of computing. It is crucial that public education take on this charge.

1.1 The Economic Importance of Computer Science Education

Computer science education is critical to national competitiveness. The demand for computer scientists and technical professionals is projected to grow 34% in the United States during the period from 2008-2018 (Bureau of Labor Statistics, 2009). Perhaps more importantly, most high-wage professions now require advanced problem-solving skills (National Academies, 2007). K-12 has been identified as a critical foundation for the building of human capital in science, technology, engineering, and math (STEM), and yet has been repeatedly found deficient in its current state (National Academies, 2007). Computer science underpins the technology sector, which has made tremendous contributions to the domestic economy, as well as to numerous other sectors that depend on innovative, highly skilled computer science graduates. The ubiquitous nature of computing reaches everyone's daily lives. Securing our cyber-infrastructure, protecting national security, and making our energy infrastructure more efficient are among numerous areas that all depend on computing. However, with the percentage of undergraduates majoring in computer science and interest at the K-12 level falling, the pipeline supplying the necessary workforce is insufficient to support current and future workforce demands.

1.2 The Current Crisis in K-12 Computer Science Education

Today's students are often required to decide their educational and career pathways as early as middle school. Studying computer science in K-12 alerts them to the fact that computer science is an exciting educational discipline and provides a pathway to a rich array of careers. Computer science also provides an important skill set for students entering any career area, including other sciences where innovation and breakthroughs increasingly depend on the contributed knowledge of computer scientists.

Unfortunately, the present public education system in the United States fails to provide so many students with the opportunity to engage in the rigorous study of computer science. Here are just some of the challenges present in K-12 computer science education:

- Participation rates by women and minorities in computer science are among the lowest of any scientific field. In 2008, only 17% of advanced placement (AP) computer science test takers were women, even though women represented 55% of all AP test takers. Participation in computer science AP tests among underrepresented minorities has increased during the past 10 years, but is only at 11%, compared to 19% of all AP test takers (College Board, 2009).
- Courses in the fundamentals of computer science often count only as a general elective, not as a college-preparatory elective, at the secondary level. Given the demands placed on college-bound high school students, it is unlikely that these students can afford to explore computer science in their already overloaded academic schedules (Computer Science Teachers Association, 2009).

- As schools have increasingly stepped up the need to integrate, use, and teach information technology, the distinctions between what is called computer science, what is information technology literacy, and the use of technology to support learning have blurred.
- Certification requirements for high school computer science teachers vary from state to state. In some cases, no computer science certification is available and computer science teachers must be certified in some other additional discipline; in other states, teachers are required to demonstrate knowledge in some discipline other than computer science (for example, business or technical applications) to teach computing/computer science courses.
- Because of the confusion between computer science and technology education, lack of teacher certification standards, and policy makers' narrow focus on core courses tested under the "No Child Left Behind Act," professional development programs for computer science teachers and research initiatives in computer science education have lagged behind other fields.

The following sections highlight the impact of these issues on schools, students, and teachers.

1.2.1 Too Few Courses

At present, all evidence points to a crisis in computer science education at the high school level. This crisis is most clearly manifested in the decreasing number of computer science courses being offered to students and the resulting drop of enrollments in computer science programs. According to six years of research collected by the Computer Science Teachers Association (CSTA, 2009), the number of rigorous computer science courses offered in high schools has dropped precipitously. Currently, fewer than 65% of schools offer an introductory-level computer science course (down from 78% in 2005) and fewer than 27% provide an AP computer science course (down from 43% in 2005). CSTA has identified a number of factors that have contributed to this situation, including:

- the lack of a national high school curriculum for computer science education,
- the chronic underfunding of computer science programs in high schools,
- the absence of relevant standards for certification of computer science teachers,
- a shortage of professional development opportunities that would allow teachers to develop and update their technical and pedagogical skills,
- the inability of school districts to attract or maintain highly qualified teachers in the face of salary and benefit competition from industry, and
- the lack of understanding on the part of students, parents, guidance counselors, and teachers about computer science in general, how it differs from other areas of computer study, and its newly developing career opportunities.

While other countries have designed and implemented national computer science education programs in order to better prepare their students for the increasingly competitive global economy, the decentralized (state, district-wide, and even school-based) educational decision-making process in the United States has severely hampered efforts to standardize our computer science curriculum and create coherence in student learning. As a result, efforts to identify research-supported best practices and to disseminate those best practices beyond the confines of localized initiatives have been hampered by:

- a persistent shortage of support resources such as hardware, software, and textbooks,
- a lack of initial and sustaining funding for computer science programs,
- and an absence of ongoing, classroom-relevant teacher preparation and training.

As a result, many students who have both the interest and ability needed to study computer science are denied the opportunity to do so, especially if they happen to be young women or minorities.

1.2.2 Profound Equity Issues

Computer science education suffers from deep equity issues that hamper the growth of U.S. human capital. Policy makers, academics, and industry leaders have long been concerned with the underrepresentation of women and ethnic minorities in science, technology, engineering, and mathematics in the United States (Camp, 1997; Camp, Miller, Davies, 1999; CPST, 2006; Jackson, 2004; Klawe, Whitney, and Simard, 2009).

Computer science is clearly one of the most alarming cases of underrepresentation. From 1996 to 2006, women's share of science and engineering graduate students increased in every field except computer science (National Science Foundation, 1996, 2006). The representation of women in computer science bachelor's degree programs decreased from 37% in 1985 to 18.6% in 2006 (National Science Foundation, 2009). Interest in computer science as a major is extremely low (National Science Board, 2008; National Science Foundation, 2007).

The public school system has not successfully met the needs of students from underrepresented minorities (CCSSO, 2004). Hispanic women earned 1.6% of computer science bachelor's degrees in 2006, even while the U.S. Hispanic population will triple between 2010 and 2050—growing proportionally from 15% to 30% of the total U.S. population (U.S. Census Bureau, 2008). Only 0.03% of all female Hispanic freshmen planned to major in computer science in 2006, the lowest of all science and engineering disciplines (National Science Foundation, 2007). African American women earn 4% of all computer science bachelor's degrees and 0.9% of master's degrees, yet represent 7% of the U.S. population (U.S. Census Bureau); Native American women earn less than 1% of computer science degrees (National Science Foundation, 2008). Underrepresentation starts long before students reach university. The disparities in achievement in STEM education between advantaged and disadvantaged student populations are seen as early as Kindergarten and increase over time (National Science Board, Science and Engineering Indicators 2006, 2008). These students are often discouraged from pursuing computer science and are especially likely to hold widespread misconceptions about computer science as a discipline and a career (Margolis et al., 2008; Stephenson 2006).

Unfortunately, recent economic conditions bring further strain on public school resources, a challenge most acutely felt in those communities serving underrepresented students. Even in schools benefiting from access to technology, classrooms are often "technology rich but curriculum poor" (Margolis et al., 2008), failing to adequately prepare students for a scientific career. Existing resources are also often designed in isolation and lack the input of the teachers working with underrepresented students. As a result, proposed solutions often lack of applicability and relevance to classroom practitioners and students.

While many agree on the critical nature of the situation, there is a lack of a shared understanding of the problems and no set of shared, actionable priorities. There is no consistent vision of what needs to be done to improve representation of women and minorities in the K-12 formal educational space and many people have given up on attempting to impact formal education because the barriers seem overwhelming.

1.2.3 Teachers under Pressure

Students are not the only ones affected by the continuing crisis in computer science education. K-12 teachers often lack adequate professional development to teach STEM disciplines despite the fact that teacher development has been deemed critical to national competitiveness in science and technology (National Science Board, 2006; Stephenson, 2006). A 2002 study of 4,000 U.S. high school computer science teachers conducted by the Association for Computing Machinery (ACM, 2005) also revealed that 89% of high school computer science teachers indicated that they experience a sense of isolation and a lack of collegial support within schools and school districts. Noting that rapid changes to both technology and teaching provide significant challenges, the teachers also indicated that their greatest professional development need was actually finding time for their own ongoing learning (CSTA, 2005). They also indicated that the ongoing battle for adequate resources, the lack of acceptance and understanding of computer science as a scientific discipline distinct from technology training, and increasing budget cuts in these times of fiscal restraint deterred many interested and qualified teachers from teaching computer science.

One additional persistent and often-ignored problem is that there is little motivation for those with the requisite skills to pursue a career teaching high school computer science. In most jurisdictions, teachers' salaries are so low and the working conditions so unpleasant when compared to other career fields, that it is impossible for education to attract individuals with the appropriate skills. Even those who are considering a second career in computer science education and for whom salary issues may not be a primary factor, the lack of consistent and readily available information concerning certification requirements make it almost impossible to determine how one should go about preparing for such a career change.

1.3 Taking on These Issues as Organizations

In 2009, ABI and the Computer Science Teachers Association (CTSA) formed a unique partnership to address our mutual concern with the crisis in computer science education, and most particularly with the continued underrepresentation of women and minority students. This relationship is based upon our mutual desire to address these issues in a direct manner at the level we believed would have the most impact—the classroom level— and upon a shared commitment to both equity and education.

The Computer Science Teachers Association

CSTA is a membership organization of more than 7500 educators. The Association of Computing Machinery (ACM) established CSTA in 2005 to deal with the crisis in K-12 computer science education. CSTA's mission is to support and promote the teaching of computer science and other computing disciplines at the K-12 level by providing opportunities for teachers and students to better understand the computing disciplines and to more successfully prepare teachers to teach and students to learn. To succeed in this mission, CSTA pursues the following overarching goal: create a community of individuals and organizations working together to address critical issues in K-12 computer science education.

CSTA is committed to achieving this goal by pursing the following five core objectives:

1 **Communications**: CSTA serves as the primary source of information and resources for K-12 computer science teachers.

2 **Standards**: CSTA works to significantly broaden the awareness of the need for curriculum standards for students and supports the rationalization of certification standards for computer science teachers.

3 **Professional development:** CSTA provides multiple levels of professional development for teachers with the goal of improving their technical knowledge and pedagogical skills.

4 **Research:** CSTA conducts and disseminates research relating to K-12 computer science education.

5 **Opportunities**: CSTA promotes computer science as a field of study and as a career destination that provides a wealth of opportunities to students regardless of their gender, race, or socio-economic status.

These goals are essential to ensuring that students have the opportunity to develop the foundational critical thinking skills and knowledge of computing necessary to every educated person living and working in our increasingly computerized world. They are also essential to providing students with the opportunity to participate in this world in a way that fully engages their learning and earning potential.

The Anita Borg Institute for Women and Technology (ABI)

Founded in 1997, ABI seeks to increase the impact of women on all aspects of technology and to increase the positive impact of technology on the world's women. ABI develops tools and programs designed to help industry, academia, and government recruit, retain, and develop women technology leaders. ABI directs and hosts the annual GHC conference and provides the program framework and logistics support for this event, as well as support for the program outreach efforts. Its three guiding strategies are to:

1 **Showcase and model the success of technical women**: ABI has a long tradition of providing role models, inspiration, and a sense of community for technical women. The ABI Women of Vision and Anita Borg Awards programs recognize the accomplishments of technical women and provide inspirational role models to women throughout the pipeline. Furthermore, GHC similarly showcases powerful role models through panels and keynote addresses, along with increased visibility to technical women at all stages of their careers.

2 **Develop the next generation of technical leaders**: professional development, knowledge sharing, and networking are an inherent part of all ABI programs. GHC emphasizes networking, community building and a strong track for career-oriented topics, such as: getting promoted, managing work-life balance, getting tenure, negotiating, or managing global teams.

3 **Influence and change the culture of technology**: ultimately, the ongoing recruitment, retention, and advancement of technical women depends on our collective ability to make computing and high-technology a more inclusive environment. ABI works with the executive leadership of top technology companies and academic institutions to engage them in changing their organizational cultures. And for the third time, ABI released a ground-breaking study of technical women in industry, conducted executive briefings, and gathered corporate and academic executives through its Technical Executive Forum at the 2009 GHC.

In order to increase the representation of women in computing, ABI firmly believes that cross-sector dialogue and action must take place. The Grace Hopper Celebration of Women in Computing is the premier platform where a large community of stakeholders from academia, industry, government, and nonprofit organizations has historically gathered to support technical women and discuss issues related to their representation. The K-12 formal education community was missing from this discussion so far, despite being critical to engaging girls and underrepresented minorities in computer science. Through a partnership with CSTA and the University of Arizona, Deanna Kosaraju, Vice President of Programs at ABI, saw a critical opportunity to integrate K-12 computer science teachers in the dialogue and provide them with the opportunity to network with change agents across sectors.

The University of Arizona

The University of Arizona is the leading public research university in the American Southwest. The UA produces more than $530 million in annual research and is the state's only member of the prestigious Association of American Universities. The University's world-class faculty creates discoveries that improve the human condition and fuel the state's economy. As Arizona's land-grant university, UA research and resources enrich communities around the state and around the world. UA is committed to making its research and resources available to the community, offering hundreds of programs, services, and educational opportunities throughout the state and around the world.

UA is home to a variety of programs that excite and engage K-12 teachers and students in STEM topics, such as the just-concluded NASA Phoenix Mars Lander mission, the NSF-funded iPlant Collaborative with an educational mission focusing on ways to incorporate computational thinking into plant biology education at all levels and many science activities at the Biosphere 2 center in Oracle, Arizona. The University of Arizona's BIO5 Institute brings together scientists from five disciplines—agriculture, medicine, pharmacy, basic science, and engineering—to treat disease, feed humanity and preserve livable environments. BIO5 creates science, industry, and education partnerships to engage in leading-edge research, translate innovations to the market, and to inspire and train the next generation of scientists.

This year, the University of Arizona was co-located with the Grace Hopper Celebration and had the greatest participation of students of all represented academic institutions. Suzanne Westbrook, Associate Head and Senior Lecturer in the Computer Science Department, was heavily involved in the planning of the 2009 Grace Hopper Celebration as Local Chair. As a complement to its existing outreach initiatives with the K-12 community in Arizona and surrounding areas, Westbrook saw a critical opportunity to extend the outreach to the region's K-12 computing teachers, provide them with resources and best practices, and engage them in a national conversation geared toward increasing the proportion of women and minorities in computer science.

USING A KEY CONFERENCE AS AN OPPORTUNITY FOR INTERVENTION AND COMMUNITY BUILDING

2.0 The Grace Hopper Celebration of Women in Computing

Co-founded by Dr. Anita Borg and Dr. Telle Whitney in 1994 and inspired by the legacy of Admiral Grace Murray Hopper, the Institute's Grace Hopper Celebration (GHC) Of Women in Computing Conference was designed to bring the research and career interests of women in computing to the forefront. GHC is the largest technical conference for women in computing and results in collaborative proposals, networking and mentoring for junior women, and increased visibility for the contributions of women in computing.

Conference presenters are leaders in their respective fields, representing industry, academia, and government. Top researchers present their work while special sessions focus on the role of women in today's technology fields. GHC has a track record of providing inspiration, role models, mentors, visibility, and professional networking opportunities to women in computing, from undergraduates to seasoned professionals in academia and industry. In its 15 years of existence, the conference has grown to 1,571 participants and demonstrated significant impact on the recruitment, retention, and advancement of women in computing studies and careers. GHC has become a central place where those working to increase the representation of women in computing exchange knowledge and establish a strong professional network. Representatives from industry, academia, and informal education hold sessions focused on the technical achievements of women, critical issues to remedy underrepresentation, and significant networking opportunities resulting in new collaborations.

2.1 Planning the Events

Prior to 2009, GHC had yet to significantly engage K-12 computer science teachers, the "first responders" leading girls to computer science careers, in the conversation. Following the 2008 conference, however, the local volunteer coordinator for the 2009 conference from University of Arizona (Suzanne Westbrook) approached ABI and suggested, after conversations with CSTA, that the conference organizers consider adding a K-12 component to GHC—specifically a workshop for teachers. The conference organizers then reached out to the Computer Science Teachers Association, who agreed to help the conference organizers create an event agenda that would provide two levels of engagement: a Town Hall type meeting that would involve the entire community (academics, industry representatives, technical women, and teachers) in a discussion of the current state of K-12 computer science education and a one-day professional development event for teachers that would focus on identifying the barriers and creating and sharing strategies for addressing equity issues. The primary objective of both events was to provide (in line with overall GHC goals) knowledge, professional development, networking opportunities, community, and inspiration to K-12 computer science teachers with an emphasis on teachers from non-traditional computer science student populations.

2.1.1 The Planning Committee

Preparation for these events was carried out by a planning committee that involved representatives from all three partnership organizations (ABI, CSTA, and UA).

Principal Investigator (PI): Telle Whitney, CEO, Anita Borg Institute for Women and Technology

Dr. Telle Whitney has served as President and CEO of ABI since 2003. Whitney has 20 years of experience in the semiconductor and telecommunications industries. She has held senior technical management positions with Malleable Technologies (now PMC-Sierra) and Actel Corporation and is a co-founder of the Grace Hopper Celebration of Women in Computing Conference. Dr. Whitney served as ACM Secretary/Treasurer in 2003-2004, and is currently co-chair of the ACM Distinguished Member Committee. She was a member of the National Science Foundation Committee for Equal Opportunity in Science and Engineering (CEOSE) and is a co-founder of the National Center for Women and Information Technology. She serves on the advisory boards of MentorNet and the Professional Business Women's Conference and is a member of CRA-W

Dr. Whitney received her Ph.D. from Caltech and her bachelor's degree at the University of Utah, both in computer science.

Co-PI: Chris Stephenson, Executive Director, Computer Science Teachers Association

Chris Stephenson is the executive director of ACM's Computer Science Teachers Association. She joined ACM after 16 years at the University of Toronto's Computer Systems Research Institute and the University of Waterloo's Mathematics and Computing Department where she designed instructional resources and professional development for high school educators. She is former president of Holt Software, an educational publishing company focusing on computer science. Since 2000, Stephenson has served as chair of the annual Computer Science and Information Technology Symposia. She is the former chair of the International Society for Technology in Education's Computer Science special interest group and of the ACM K-12 Task Force. She is also a former president of the Association for Computer Studies Educators and of the Educational Computing Organization of Ontario, Canada. She has produced numerous research publications in the field of computer science education and adaptive technology and has written several high school textbooks. Stephenson earned a B.A. in English Literature; a B.J. (Journalism) from Carleton University; an M.Ed. from the Ontario Institute for Studies in Education with a specialty in Computer Applications, Measurement, and Evaluation; and a Ph.D. in Education and Teaching Leadership from Oregon State University.

Co-PI: Suzanne Westbrook, Associate Head and Senior Lecturer, Department of Computer Science, University of Arizona

Suzanne Westbrook is a Senior Lecturer and Associate Head in the Department of Computer Science at the University of Arizona. Her past research was on multi-paradigm programming languages and software understanding. More recently, her research has examined gender issues in computing education. She is a member of the Education, Outreach, and Training team of the iPlant Collaborative project and is the acting Associate Head of the new (in 2010) University of Arizona School of Information: Science, Technology, and Arts (SISTA) which will provide an interdisciplinary curriculum based on computing across disciplines. She has been at UA since 1999 and was previously at Northern Arizona University between 1993 and 1999. She received a BS in Computer and Information Sciences (Systems track) from the University of South Alabama and an MS and a Ph.D. in Computer Science from the University of Southwestern Louisiana (now The University of Louisiana, Lafayette).

Program Lead: Deanna Kosaraju, Vice President of Programs, Anita Borg Institute for Women and Technology

Deanna Kosaraju is Vice President of Programs at the Anita Borg Institute for Women and Technology. She came to ABI after spending 20 years in the high-technology industry in Silicon Valley startup companies where she held positions of increasing responsibility. She was the Vice President of Customer Success at BizFinity, Director of Applications at BitLocker, and Senior Product Marketing Manager at AphaBox. Kosaraju was named a Silicon Valley Women of Influence in 2010. Kosaraju holds a B.A. in Gender and Women's Studies from the University of California Berkeley.

To ensure that the event planning and delivery was well grounded in both K-12 realities a practical understanding of equity issues, three additional members with a great deal of expertise in these areas were added to the committee.

Caroline Simard, Vice President of Research and Executive Programs, Anita Borg Institute for Women and Technology

Dr. Caroline Simard directs the Anita Borg Institute's (ABI) research initiatives. She has led the design, data collection and analysis, writing, and dissemination of the Institute's major research initiative: "Climbing the Technical Ladder: Obstacles and Solutions for Mid-Level Women in Technology," which has received national media attention. At ABI, she is spearheading knowledge diffusion efforts and executive engagement programs directed at supporting organizational change for greater retention and advancement of technical women. Simard is passionate about social science research and its role in creating practical solutions to social problems. Prior to ABI, Simard was a Researcher at the Center for Social Innovation of the Stanford Graduate School of Business. Caroline holds a PhD in communication studies from Stanford University, with a focus on organizational theory, high-technology industries, and social networks. She holds a Bachelor's Degree from Université de Montréal and a Masters Degree in Communication and Information Studies from Rutgers University.

Betsy Frederick, Educator

Betsy Frederick is a long-time computer science educator in the state of New Mexico and has, for many years, served as the Director of the New Mexico Super Computing Challenge, a unique program that offers students in grades 6 through 12 (most from high-minority and high-poverty schools) an opportunity to solve interesting and challenging problems using high-performance supercomputers. Frederick is also a long-time member of the planning committee for the annual Computer Science and Information Technology Symposium.

Tori Griego-Jones, Professor, Teaching and Teacher Education, University of Arizona

Dr. Tori Griego-Jones is a Professor of Teaching and Teacher Education, University of Arizona who brought a wealth of experience as both an academic and a volunteer with the Hispanic community. Dr. Griego-Jones is a specialist of teacher development for Hispanic and Latino/a students. Her 2003 book, *Teaching Hispanic Children*, explored the critical success factors to student engagement. Griego-Jones is also a founding member of the Tucson Hispanic Coalition and has worked with numerous schools in Arizona on teacher development for teaching Hispanic students.

Evelyn Torres-Rangel, Educator

Evelyn Torres-Rangel is a long-time educator in the California public school system and is currently teaching at Gabrielino High School. In addition, Torres-Rangel serves as the volunteer President of the CSTA Southern California chapter. Torres-Rangel has worked at both the state and national level to increase the engagement of underrepresented minorities in computer science.

The planning committee met for a full day to plan both the Town Hall and workshop. Agendas were drafted for each event and potential speakers were identified. Committee members then took responsibility of contacting the speakers, creating the final agenda, and moderating various sessions during the Teacher Workshop. ABI assumed all responsibilities for disseminating invitations, overseeing registration, providing on-site event management, and coordinating the project evaluation. CSTA assisted with the speaker confirmation and liaison work and managed the application review process.

2.2 Selection and Profile of the Attendees

To facilitate the selection of teacher attendees, ABI set up an application process that required the teachers to provide the following information:

- Name
- School
- Phone
- Email
- What they teach:
  - Computer Science
  - IT
  - Applications
  - Math
  - Science
  - Other (please specify)

The applicants were also required to provide answers to the following questions:

- What kind of equity challenges do you see in your teaching practice? Please describe them.
- What do you see as the biggest challenges to engaging more students in K-12 computing?

Invitations to apply were sent using both direct mail and several email lists that were known to be used by computing teachers. These included the complete CSTA membership list (more than 5,000 U.S. teachers) the SIG Computing Teacher list, and the Advanced Placement Computer Science list. In addition, ABI sent more than 2,000 hardcopy invitations by postal mail to teachers in the following states: AZ, NM, CA, and CO.

Perhaps the most surprising aspect of the event planning was the sheer number of teachers who applied to attend the workshop. ABI received a total of 650 applications. The planning committee reviewed all of the applications using the following criteria for the final selection:

- Representation from the elementary, middle, and secondary level
- Preference for schools with high minority ratios
- Teacher experience in computer science or specialized knowledge (such as ESL teachers or those teaching at reservation schools)
- National representation with a strong emphasis on teachers from AZ, CA, NM, CO, NV, and UT (to support the building of local community in proximity to the GHC conference event site)
- Gender equity among attendees
- A knowledge of and commitment to equity issues in the classroom (as evidenced by the answers to the posed questions)

Upon selection, ABI contacted potential participants to confirm their availability and to make their travel and accommodation arrangements. Of the 110 teachers selected, 78 teachers accepted the invitation and participated in the Town Hall and the workshop. In addition, 19 committee members and speakers (many of whom were also teachers) received a scholarship for participation, for a total of 97 participants. The distribution of the participants was as follows:

- 88% were teachers from public schools
- 13% were teachers from private schools
- 18% were committee members, speakers, and funder representatives.

The proportion of underrepresented students served in applying schools was gathered using *The Common Core of Data (CCD)* of the U.S. Department of Education's National Center for Education Statistics. Of the public schools represented at the workshop:

- 50% were serving a majority of non-white students (fewer than 50% white students), of which:
  - – 35 schools had more than 50% underrepresented minority students and 44 with more than 40% underrepresented minority students
    - 4 schools with 100% Native American student population
    - 23 schools with more than 50% Hispanic population and 11 more than 80% Hispanic student population
  - – 3 schools more than 50% African American students

2.3 Acknowledged Challenges

The planning committee faced a number of challenges in organizing these events. Some were specific to this event and some are likely to be common to any event involving large numbers of teachers. These challenges relate primarily to event timeframes and planning for teacher travel and accommodation.

As noted above, the committee was somewhat overwhelmed by the number of applications it received for this event. We believe that there are several factors that contributed to the level of teacher interest. First, teachers, especially computer science teachers, are exceedingly aware of the importance of keeping their skills current through participation in professional development events and there are very few events specifically designed to meet their needs. In addition, the provision of travel funding for this event made it significantly more attractive to teachers who are usually required to cover their own professional development costs and for whom these expenses may prove a major barrier. Finally, the response indicates that computer science teachers are very aware of issues relating to equity and are actively searching for strategies and solutions to the barriers that they and their students face.

The other significant challenge for the planning organizations centered on the challenges of managing attendee travel and accommodation. The current complexities of cross-country travel made it exceedingly difficult to estimate travel costs for the participants. Specifically, the need to provide additional accommodation for attendees who required extra travel days due to lack of flight availability made limitations a constant worry. In addition, teachers often had special requests with regard to travel and accommodations that needed to be managed on an individual basis, significantly increasing the amount of work for the event staff.

The final challenge faced by the organizing committee relates to the importance of engaging the larger community represented at GHC in these critical issues of equity and computer science education. GHC is an incredibly dynamic venue with numerous simultaneous events competing for the attention of the conference audience. The planning committee felt that, given more advanced warning of the Town Hall, more could have been done to provide information about the importance and relevance of the event to conference attendees. Also, given more lead time the conference schedule could have been adjusted to reduce the number of competing events at the time of the Town Hall.

3.0 Town Hall Participation

Event organizers set a goal of 250 attendees for the Town Hall event and 100 teachers for the K-12 workshop. Attendance at the Town Hall was open to the entire GHC community in addition to the teachers who would be attending the workshop the following day. Participants in the Town Hall included 212 people. Although this number was slightly smaller than the committee had hoped (due to competition from several simultaneous conference events) the goal for broad community participation was achieved, with the following percentages of attendees representing the various stakeholder groups.

- 53% of attendees from K-12
- 23% of attendees from academia (higher education)
- 13% of attendees from the nonprofit sector
- 8% of attendees from industry
- 3% from government

3.1 Town Hall Format

The Committee planned the Town Hall event as a way of engaging the broader community represented at GHC in the challenges faced by K-12 computer science educators. The event was attended by 212 attendees including K-12 educators, college and university educators, nonprofit representatives, and industry representatives.

Michelle Hutton, President of the Computer Science Teachers Association and a computer science teacher at the Girls' Middle School in California, moderated the Town Hall.

Hutton set the context for the event, outlining the current state of computer science education in K-12 and briefly acknowledged some of the pressing issues facing educators and students.

She noted that the focus of the discussion would be on equity issues (broadly defined to include gender and underrepresented minorities) in formal (rather than informal) education. Hutton also provided the following ground rules for the discussion:

- No ranting
- No complaining
- No promotions for your pet project
- Just talk about the issues as you see them, what challenges you have faced, what successful strategies you have found, how you think we can work better together
- Listen to the voices of the teachers

Following Hutton's introduction, Dr. Jane Margolis gave what the organizers referred to as the "charge to the audience." Her task was to serve as an "agent provocateur," helping to stimulate engagement with the profound issues of equity and promote a lively and open discussion among the attendees. Margolis' session lasted approximately ten minutes and covered the following topics:

- Why do we care about equity?
- Why do we need to define it more broadly?
- Why can we not afford to give up on formal education?
- Why do we need to work beyond the scope of our individual funded projects?

Three critical observations emanated from Margolis' context setting:

1. Computer science is not an isolated island, but a part of a national educational crisis.
2. It is difficult to affect change in the public educational system, but we can't bypass the public schools if we hope for nationwide educational change.
3. The teachers are the "community organizers" from whom change stems.

The remainder of the event consisted of a series of intensive, small group brainstorming sessions followed by whole group report-out and discussion. There were a total of three such sessions, each focusing on one of the following questions:

1. In your own experience, are computer science classes diverse? If not, what are the barriers to equity in the classroom?
2. What have you seen that has worked well to address equity challenges?
3. How can we collectively address the problem and accelerate change? What can you do as teachers to improve equity going forward?

Hutton concluded the event by noting that the barriers articulated through the group discussion, not only highlighted the extent to which equity was both a systemic education challenge and a wider economic and social issue, but also pointed to the critical importance of engaging the broader community in attempts to overcome these barriers. This, she noted, is a good place for the community building to begin.

3.2 Teacher Perspectives on Equity Issues in K-12 Computer Science Education

The Town Hall discussion was extremely broad-ranging, covering both in-school and out-of-school realities and all of the systemic challenges present in the education system. If a single message can be drawn from these discussions, however, it is that **the digital divide is alive and well and continues to impact student's lives at school and at home**. The following subsections will provide a more in-depth look at the specific barriers to equitable computer science education K-12 educators identified.

3.2.1 Lack of Home Access for Poor and Underrepresented Students

Teachers highlighted the lack of access and exposure to information technology for underrepresented students who tend to come from poor communities. One teacher, whose school's student population is 70% Hispanic, lamented that students have not been exposed to computers before entering his class: "*I would like to see all of our students be required to take at least a basic computing class. Many of my students (male or female) have never had access to a computer until they take a class. My class is composed mainly of male students. I would like see more females to take this course.*"

Another teacher, in her application to participate in the workshop, provided a vivid commentary on the deep disparity in technology access felt by her community of Navajo students: *"How can a traditional native, rural, Navajo society catch up to the rest of the world? Our students grow up hauling wood and water, without access to electricity let alone the Internet. It is my job to give Navajo students the best, up-to-date technology skills and information available."*

One teacher similarly described the daily struggle involved in meeting the needs of a large immigrant and poor community: "*68.2% of our students qualify for free or reduced lunch, and 36% of our students are English learners, with one of the largest newcomer populations in the district. We teachers struggle daily to provide students structure and empowerment despite often volatile home lives.*"

The observations made by these participants reflect similar patterns identified by researchers. For example, Jane Margolis, Senior Researcher at UCLA and author of *Stuck in the Shallow End: Education, Race, and Computing* (Margolis et al., 2008) points out that in schools with high numbers of students of color, computer science classes (critical thinking, algorithms, robotics, as opposed to applications classes such as word processing) rarely exist. These underrepresented children are also less likely to have access to computers at home or to have parents who encourage them to study computer science.

3.2.2 Lack of Access Inside Schools and Absence of Dedicated Resources

While the participants in the workshop self identified as computer science or computing teachers, many of them are charged with teaching multiple disciplines and are teaching computer science without infrastructure or curriculum resources from their schools. One teacher from New Mexico lamented: "*New Mexico is one of the poorest states. We don't have computer classes. Students don't have access [at home or at school].*"

Participating teachers in some schools described being limited to teaching technology applications with no curriculum space for computational thinking. Some of the participants also noted the profound impact of funding cutbacks. Others pointed to the shortage of appropriately trained teachers. One educator who teaches in a school where 90% of the students are Hispanic noted: "*Computer labs in some districts have been dismantled and students are unaware of what programming/ computer science is all about because not many teachers even dabble in programming, teach networking, or open up a computer for students to examine.*"

Others pointed out that, despite the technology being present in the school, a layer of bureaucratic rules around access prevents teachers from accessing necessary tools and resources. Many teachers talked about their own emails being blocked from access within schools, as well as some of the most helpful educational websites. One teacher from Ohio said that he used his own time to ensure there would be appropriate Internet resources for other teachers: *"I whitelist every site that teachers tell me is blocked and unlock them."* The participants also noted a pressing need for industry to bring technology to the public educational system and support appropriate access.

Many computer science teachers also mentioned that they are called upon to serve as their entire school's "IT department" and that these responsibilities detract from their teaching responsibilities; one teacher said: *"on our own time, we end up fixing everyone's problem and teaching others how to use technology."* And even participants teaching in schools with dedicated IT departments argued that these departments were not sufficiently staffed or had resources to adequately support teaching activities and were, as a result, frequently unresponsive to teachers' needs. One teacher discussed routinely bypassing his IT department to teach using the tools he deemed necessary: "*The tech guy asks 'what is this program on this computer?' I do it anyway.*"

3.2.3 Lack of Stakeholder Awareness and Understanding

Teachers agreed that igniting student interest in computer science, especially in the case of girls and underrepresented minority students, is a significant equity challenge. Many girls and underrepresented students are unaware of the career possibilities open to them by studying computer science. Parents, counselors, and other teachers are also either misinformed about computing careers or unaware of the existence of the field and are unlikely to encourage children to pursue computer science education.

For some school districts, while the parents are aware of computer science as a career destination, they are exceedingly misinformed about job opportunities. One participant commented that: "*Parents think all the jobs are outsourced to India/ China.*" Another teacher pointed out that even parents who are currently employed in computing careers were not necessarily encouraging their children to enter the field: "*Our high school is in a technology corridor and has been hit hard by layoffs of technical people. Consequently, parents advise their children to avoid programming courses.*"

For other districts, parents are unaware of even the possibility of a computing career for children. One teacher who works in a Hispanic majority school commented: "*I work in a district that is only 30 miles from the Mexican border. I see the girls looking at traditional female careers. We also have a very low income level in our county. Many of our students' parents are farm laborers and have a low education level. We need to open the doors to females.*"

One of the biggest challenges participating teachers experienced is a lack of awareness and support from their own colleagues, often resulting in a debilitating dearth of resources: *"My department and the administration do not understand what I am doing in here, so it is hard to get their support for new initiatives, such as bringing in an Alice course or a network class."* As one teacher noted, educating school administrators and policy makers regarding the importance of computer science education "is as important as running water."

A lack of awareness and accurate information also exists for student counselors in K-12, who are sometimes discouraging students from considering a career in computer science or enrolling in the computer science classes. As one teacher put it: *"getting counselors to understand computer science is a challenge."*

One teacher who noted that he is now making reaching out to counselors a priority:

"The challenge of educating counselors is my goal for this year. The counselors have the capability of channeling students into computer science. They need to be made aware of what the course is and guide the students into making the decision to enroll in the course. This year I plan to meet with each counselor to discuss what computer science is and brainstorm ideas about how to encourage more students to enroll."

3.2.4 Lack of Student Interest

A lack of interest from all students is often linked to the lack of awareness and a lack of accurate information, as discussed above. In the case of girls and students of color, however, the participants identified several additional factors. The teachers discussed their ongoing struggles to interest students in computing classes, especially young women and underrepresented minority students. They agreed that looking in-depth at their pedagogy and asking whether their curriculum was truly engaging and inclusive for a diverse set of students was an important activity for them to undertake on an ongoing basis. One teacher wrote in the application: "*Academic Hospitality is a term I like to use in describing how well students are treated in the academic realm. I have no fear that I am not personally hospitable, but from time to time I feel that the methodology I use causes students (especially women and minority) to feel somewhat alienated."*

The participants also acknowledged that students who had no previous exposure to computing or to technology in general were more likely to be from lower socioeconomic backgrounds. They noted that these students often enter their first computer science classes with lower self confidence and a weaker set of foundational concepts and skills and thus require significant remediation efforts. Despite their dedication to these students, the teachers noted that working on their own to design a curriculum that meets the needs of those with and without previous computer science exposure is exceedingly challenging.

Several participants commented on a negative trend in their classrooms in terms of recruiting and keeping a diverse set of students: *"Over the past few years enrollment for girls and minorities in my computer science classes have steadily reduced. This has troubled me and has continued to be a challenge for the computer science academy, since our program is built to inspire, encourage, and prepare students for careers in IT."* The participants also agreed that girls were more likely to participate in less technical technology courses such as graphic design or digital photography: *"Although young women often take digital photo and multimedia classes, they rarely take classes that are more technical and 'geeky.'"* The teachers had also observed that the lack of critical mass of underrepresented students makes retention more difficult by signaling to diverse students that their peer group is not engaged in the class: "*In my school, if one Hispanic student comes to my class and there aren't other Hispanic students, they will walk out*."

Even teachers in schools where AP Computer Science is being offered lamented the lack of student interest in computer science courses:

"The first challenge of finding curriculum for the introductory course has been ongoing for the last few years. I am currently looking for curriculum for this course that would be accessible to all students and prepare them for AP Computer Science. Over the last few years I have tried several approaches, but they have not been as successful as I had hoped. Very few students choose to take AP Computer Science the following year. I want to find a curriculum that would break this trend."

3.2.5 Absence of Curriculum and Certification

During the application process, participating teachers were asked to list the subjects they were teaching. On average, the teachers teach 2.6 subjects. Some teachers are responsible for the entire science or mathematics curriculum of their schools or are teaching non-STEM subjects, such as business or English, in addition to their computer science courses.

The fact that computer science is not a "core course" is experienced as a critical barrier by teachers: *"Technology should not be an elective in the twenty-first century*," said one participant. In some states, a technology credit is no longer required for graduation. That one credit, while not exclusively focused on computer science, was a key vehicle for teachers to promote computer science curricula and get support from their administrators.

Teachers in schools where computer science is offered as an elective credit also argued that the shift among states and districts to increase the number of math and science credits required for graduation is exacerbating the difficulty of attracting students to computer science courses. As a result, teachers are anxious to see efforts to lobby education authorities to accept a rigorous computer science course as a math or science credit for graduation purposes. The teachers noted, however, that individual efforts to convince policy makers to change existing policies are often unsuccessful and a more organized and systematic approach would prove more effective and have a greater impact on more students.

Teachers also expressed the conviction that advocacy is critical to addressing the current problems with teacher certification requirements. And while the teachers applauded the work of CSTA in this area, they were not unanimous in their opinions regarding their own responsibilities for advocacy. Some view personal advocacy within their district and the state as a "necessary evil" because it means more time spent away from the students. Others prefer acting at the local level. Both approaches—top-down and bottom-up—were deemed necessary for fostering change.

One teacher from a well-funded school also pointed out that curriculum reform needs to happen before high school. In his experience, many gifted students are lost because they haven't had exposure to computer science before entering high school. But a female graduate student participating in the Grace Hopper Celebration pointed out that neither she nor most of her colleagues had computer science exposure before high school, and questioned whether pre-high school exposure was a critical factor.

3.3 Sharing Strategies that Work

Despite intractable barriers, participants in the Town Hall engaged in a lively exchange on solutions and delivered a strong call to action that focused on recruitment and partnerships.

3.3.1. An Unrelenting Focus on Recruiting Students and Dispelling Myths

The teacher participants felt an ongoing focus on recruiting students and dispelling the myths and misconceptions about computer science as a discipline or a future career is absolutely critical for addressing computer science education pipeline issues and improving the participation of underrepresented student minorities. The teachers evidenced a deep wealth of ideas and experiences around recruitment and used the Town Hall as a platform for sharing their strategies.

Computer Science Teachers' Experiences

Teachers who had the most participation in their computer science classes discussed their recruitment methods. For many participants, this involves engaging in their own "image campaign" within their school and spending considerable time outside the classroom talking to prospective students.

One teacher, an African-American woman drawing from her own experiences, noted several proven strategies she has used to encourage students to take her computer science courses. She created a "road show" involving demos to show students the most engaging side of computer science. In this road show, and in all of her initial conversations with students and parents, she emphasizes terms such "robotics, artificial intelligence, movie animation…" Once she engages students with the demos, she brings in the concept of computer science. She has found this approach to be particularly effective when students hold misconceptions about the discipline.

Another participant emphasized investing time in building the self-confidence of girls and underrepresented minority students who engage in computer science but tend to leave early because of the belief that they are not as good as their peers: *"Often the girls and minority students in my class think 'I don't belong here, I am not as smart.' We need to be building student self confidence and saying 'yes you can do it!' I passed out progress reports to everyone. We compared progress reports and showed them they got the same grade as the others."*

Some teachers had had significant success in recruiting girls and underrepresented students by taking the time to talk to individual students and encourage them to try their computer science class: *"I go and find them in all of their classes and advertise my computer science class."* One teacher also described relentlessly repeating this process of recruitment across schools after his program got eliminated at various steps in his career:

"At every school I have gone to, I take time to make the connection with kids and get them excited, and then the program grows. After 10 years at a previous job, the Superintendent eliminated the computer science program I built. I went to another school and did it again. Now I am in California, and I thought this would be the computer capital of the world. But we are forty-eighth in funding and there is no curriculum. So I started a course again, engaging diverse students, they are doing exciting things, they will get a lot of visibility, and I will disseminate their activities and then the program grows."

Through Partnership with Colleagues

Remarking that most students who excel in computer science start out by excelling at math, some teachers targeted their recruiting efforts through the math classes offered at their school, enlisting the support of their colleagues teaching math. This targeted effort yielded a significant enrollment increase for a participating teacher: *"Last year I prepared invitations to students to register for computer science and asked mathematics teachers to distribute the invitations and run a presentation I had prepared. In this presentation I used the theme of the current CSTA poster and highlighted some projects the current students had completed. My enrollment in AP computer science has doubled for this year."*

Another teacher agreed with this approach, extending his outreach to all math, applications, and science classes. *"I gathered interest through the Applications class; I start by teaching them to code in HTML so they can learn something quickly and with cool factor. Eventually this feeds into the AP class. There is a tie between computer science classes and scores for math and science. We can go and look at our student test scores. We can tie back to the math scores and learn how to bring them in the computer science curriculum."*

Working in partnership with other teachers was extensively discussed at the workshop. One of the key barriers computer science teachers experience in enrolling more students is the limited understanding and exposure to computer science concepts and to technology in other classes. Computer science teachers welcomed the idea that computing concepts, in addition to being a core course, need to be better integrated into other disciplines to provide ongoing exposure for students.

3.4 Strong Partnerships

The most powerful accelerator of change that a limited subset of teachers experienced was the establishment of strong partnerships with industry and academia. A general consensus emerged that there aren't enough partnerships happening across sectors to boost K-12 computer science education.

3.4.1 Partnerships Across Multiple Education Levels

University faculty has the opportunity to play a critical role in supporting K-12 computer science education. They have access to the latest research on computer science curriculum development and they experience first hand what students need to be successful in post-secondary computer science courses. One teacher talked about her relationship with Carnegie Mellon University's Computer Science department in accessing curriculum and technological support for her program: *"I can interact with academics to keep abreast. They have helped tremendously in donating computers and also ideas. I can make sure our curriculum is aligned with their recruitment practices. They then know our students are prepared going in."*

A faculty participant from Harvey Mudd College lamented that these types of partnerships are not happening on a broader scale: *"I have had the opportunity to work with people developing the Advanced Placement course. I am struck with how little communication there is between faculty and high school teachers and vice versa. We are all working toward the same goals. I want more kids coming in and more diversity. What can we at college level do systematically?"*

A broad call for academia-K-12 partnership emerged. Teachers and faculty need support in making these connections and called on the workshop hosts (ABI, CSTA, the University of Arizona) and all of the academics and industry representatives to think about facilitating these connections.

3.4.2 Partnerships with Industry

Participants from industry noted that they all engage in K-12 outreach and fund programs designed to get more girls and underrepresented students involved in computing. However, they tend to have greater connections to informal K-12 education efforts rather than formal public education. As is the case with faculty, the network connections between public education and industry are not well established.

One teacher was successful in fostering these connections by virtue of having been employed in industry before his teaching career. He discussed calling on his former colleagues to come and give technical demonstrations to his students, noting the cultural importance of providing students with role models with whom they can identify and technologies that engage their interests.

By and large, both teachers and industry participants reported that they had had few opportunities to interact before coming to the GHC Town Hall. Participants from all sectors acknowledged that more of these discussions need to happen and that partnerships need to be established and sustained across sectors to achieve systemic change.

4.0 The Workshop Format

The primary objective of the workshop was to provide professional development and networking opportunities to K-12 computer science teachers with an emphasis on teachers from non-traditional computer science student populations. Toward this end, the workshop's main goal was to instigate a discussion of equity and computer science curriculum and to foster the sharing of best practices for overcoming acknowledged barriers to equity.

The workshop consisted of two general sessions attended by all workshop attendees and five presentations grouped into two breakout sessions. The first general session featured Dr. Jane Margolis, the author of *Stuck in the Shallow End: Race, Education and Computing*. It focused on the efforts of the Los Angeles Unified School District (LAUSD) to overcome the severe inequities in computer science education that permeated the district's schools. Margolis began her presentation by reviewing the results of an extensive study that revealed systemic inequities of access to computer science education. Describing access to rigorous computer science courses in high schools as "privileged knowledge," Margolis detailed the extent to which this knowledge was being denied to students in schools typified by high-minority populations, regardless of student interest. Margolis also noted a deep-seated morass of prejudices with regard to student ability and a complex system of bureaucratic and systemic barriers that perpetrated the continued denial of this privileged knowledge. She then outlined the details of a massive intervention undertaking by the original researchers and LAUSD to address these systemic issues. This intervention involved stakeholders at all levels and focused on providing: 1) professional development for teachers 2) remediation and college preparatory experiences for students 3) the development and distribution of teaching materials and curriculum, and 4) the commitment of district and school administrators to ensuring that courses would be offered. All of these were indentified as contributing to remarkable increases in minority student enrollment in computer science courses.

The first breakout session provided the workshop attendees with a choice of three presentations. Betsy Frederick and Dr. Tony Griego-Jones facilitated a follow-up discussion among teachers and Margolis focusing on the details of the LAUSD project. Dr. Irene Lee, from the Growing up Scientifically Thinking (GUTS) project, led a session on engaging activities to embed computational-thinking concepts across the curriculum. Finally, Dr. Jan Cuny from the National Science Foundation and Dr. Chris Stephenson from the CSTA provided a presentation and facilitated a discussion on upcoming changes to the Advanced Placement Computer Science (APCS) program. They also detailed an ambitious plan to support the new APCS Principles course with a broad-ranging program that would support the teaching of the new APCS course in 10,000 schools. This plan includes professional development for teachers and access to online resources for both teachers and students. During the second breakout, workshop attendees had a choice of two sessions: Robb Cutler provided a highly engaging session on how to teach computer science concepts using toys and manipulatives while Dr. Chris Stephenson and Evelyn Torres-Rangel presented a session on strategies for recruiting more students to computer science courses.

The final general session of the workshop was a panel including Dr. Audrey Bennett from Rensselaer Polytechnic Institute; Dr. Ann Gates, Associate Vice-President of Research, at the University of Texas, El Paso; and Cynthia Mruczek from the CompuGirls project at Arizona State University. Betsy Frederick facilitated the session, which explored culturally relevant tools for computing. It began with brief presentations by each panelist during which they gave examples of various effective tools for teaching computer science concepts in a way the resonated with diverse cultures. Frederick then asked each of the panelists to address the following three questions:

- We are reading and hearing about "culturally relevant computing" or "culturally relevant technology" or "culturally situated" or "culturally responsive" computing. Help us understand these descriptions and tell us about how your work addresses "relevant and responsive" computing.
- What is your sense of the students' commitment to or enthusiasm for continuing study or career preparation in computing or technology following their experiences in your programs?
- Do you think that the practice of setting cultural contexts can become widespread in the teaching of computer science and information technology? That is, will it be part of what is being called "Culturally Relevant Pedagogy?" What are the conditions that will propel change and what are barriers?

The workshop concluded with a final wrap up facilitated by Dr. Jane Margolis, followed by a raffle during which more than 30 donated prizes were distributed to the teachers. Following the workshop, University of Arizona undergraduate students also conducted campus tours for interested attendees.

4.1 Results of the On-Site Evaluation

Directly following the workshop, attendees completed a paper evaluation survey. This survey was collected and tabulated by an external evaluator, Rockman and Associates, and the results were then distributed to the workshop Planning Committee. The remainder of this section provides the results of the evaluation. The full evaluation report produced by Rockman and Associates is available at www.anitaborg.org.

4.1.1 Participant Perspectives and Motivations

Participants were asked how concerned they were about engaging diverse students in Computer Science/Information Technology prior to the workshop. As Figure 1 shows, a majority (57%) were "very" to "extremely" concerned (M=3.64) and only one respondent indicated they were not concerned about this issue at all.

Participants were also asked to indicate why they chose to attend the workshop. While they indicated multiple reasons, Table 1 (below) shows that the most common were "to discover new teaching strategies" and "to become part of a community" (80.8%, each).

Table 1: Reasons for Attending Workshop

Reasons for Attending Workshop	% Who Selected
To discover new strategies for teaching computer science/information technology	80.8%
To become part of a community that would share best practices and resources	80.8%
To find new tools/resources to use in my program	76.9%
To learn new strategies for attracting students to my courses	69.2%
To learn more about equity issues	64.1%
Other	16.7%

"Other" reasons participants gave for attending included starting a computer science program at their school and for one: *"Technology is my passion and for our young generation this is how they communicate and prefer to learn."*

When asked how well their expectations for the workshop were met, no respondents selected "not at all," and only one selected "slightly." Approximately half (46%, M=4.14) indicated their expectations were "very well" met. (Figure 2, right.)

As Table 2 (below) indicates, workshop ratings were extremely high across the board, with 97.4% of respondents rating the overall quality as "good" or "excellent" (M=4.65).

Table 2: Rating of Workshop Elements

Workshop Element	% Good/ Excellent	Mean (5 point)
Overall quality	97.4%	4.65
Relevance of topics	97.4%	4.62
Insight into equity issues	97.4%	4.67
Build community of educators	94.8%	4.53
Interact w/Other CS Professionals	73.1%	4.12

Figure 1: Level of Concern About Engaging Diverse Students Prior to Workshop

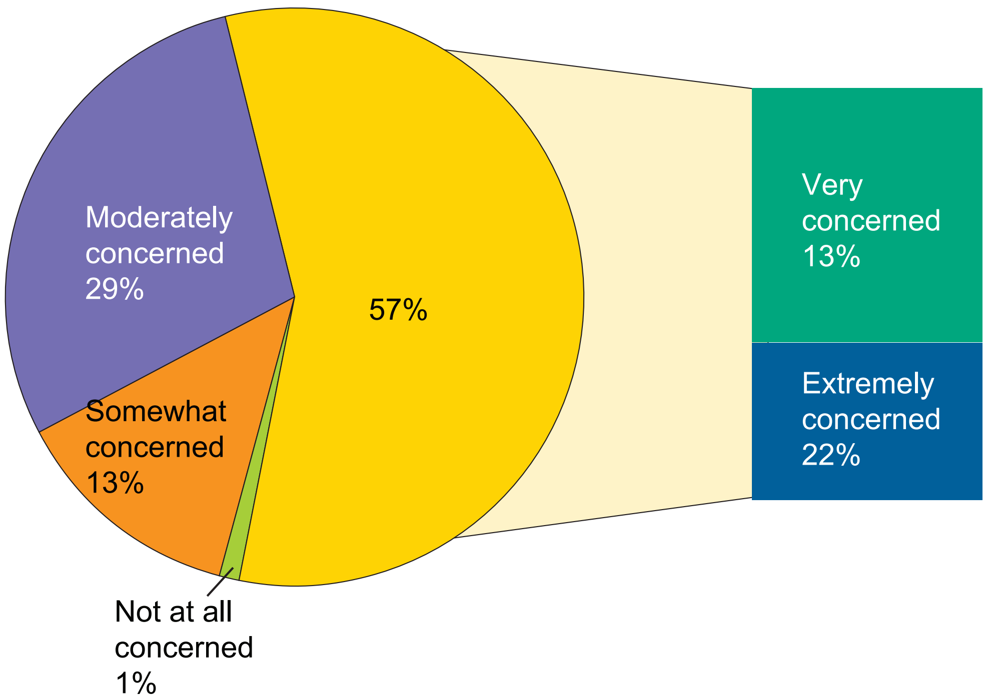
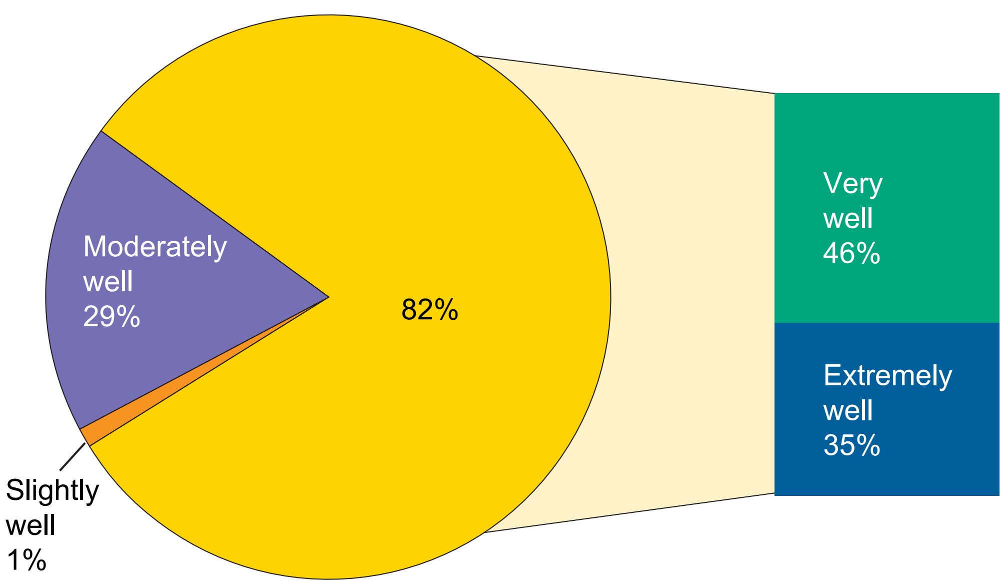


Figure 2: How Well Participants Expectations Were Met



The "ability to interact with CS/IT professionals outside the workshop" received the lowest ratings. Still, nearly 75% rated the workshop as "good" or "excellent." Moreover, as Table 3 shows, 87% indicate that participants felt they were a part of a community of educators and professionals. With one exception, participants "agreed" or "strongly agreed" they would recommend this workshop to other educators (M=4.73).

Table 3: Ratings of Workshop Elements

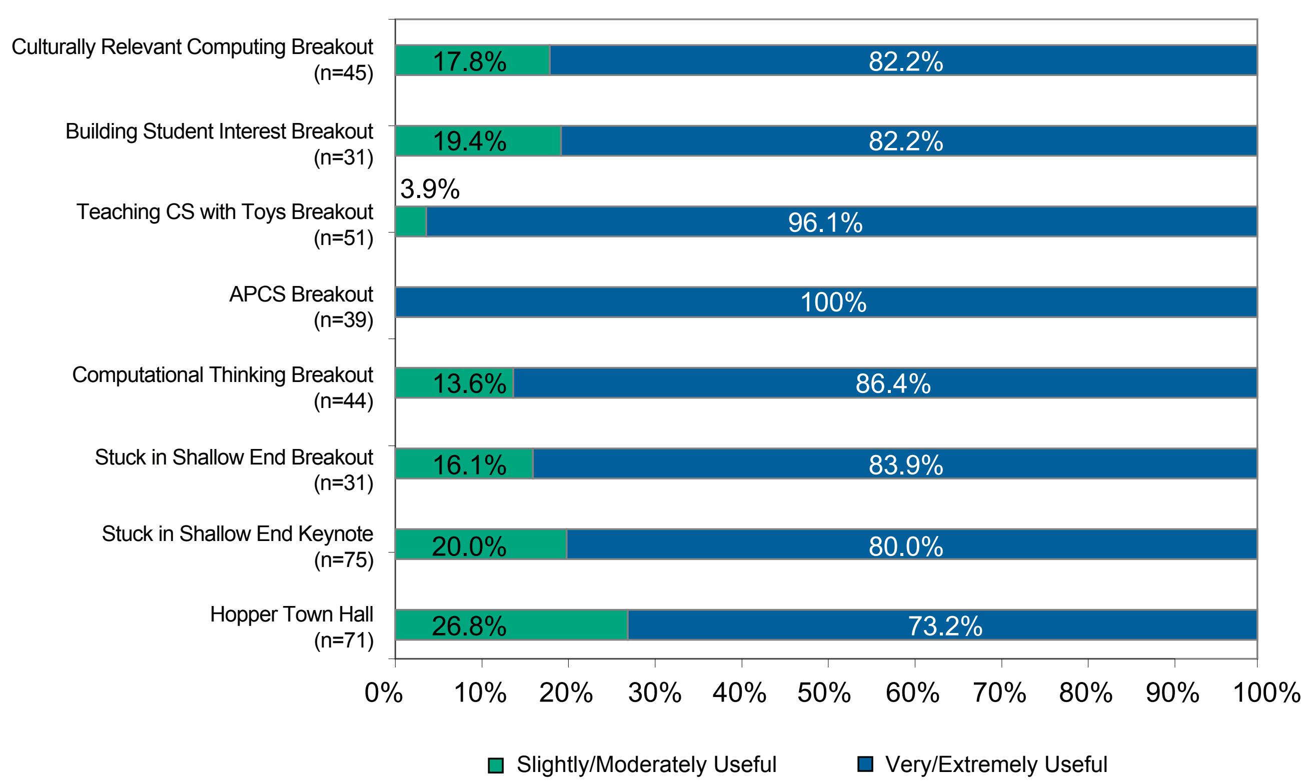
Workshop Outcome Statement	% Agree/ Strongly Agree	Mean (5 point)
I would recommend this workshop to others	98.7%	4.73
I can implement what I learned	96.2%	4.32
I have access to new resources	94.8%	4.47
I learned new strategies to attract/teach diverse students	92.3%	4.22
My concerns were addressed	88.5%	4.15
I feel part of a community of educators & professionals	87.0%	4.25

Participants were also asked to rate the individual sessions they attended (n's vary as participants chose among breakout sessions). As Figure 3 shows, the vast majority of participants rated each session as "very" or "extremely" useful, including all who attended the APCS breakout session.

When asked to indicate their favorite session, the "Teaching Computer Science with Toys" breakout received the most mentions by far (28). Regardless of *which* session was mentioned, though, participants repeatedly used the following words to describe favorite sessions: practical, relevant, concrete examples, and can implement today.

Participants were also asked what the highlight of the event was for them. Again, a common theme emerged. Nearly every response mentioned something about connection and communication—talking, meeting, networking, and sharing ideas. Some participants also mentioned getting new information and resources as a highlight.

Figure 3: Usefulness of Each Session



4.1.3 Future Events and Opportunities

Participants were asked which item on a list of future opportunities and events would be most helpful to them. As Table 4 (below) shows, more than 80% of participants were interested in additional tools and resources, another gathering, and website that offered the ability to connect and network. Among the "other" responses, suggestions included: having local meetings/seminars, help with applying for (technology) grants, and the development of mentoring groups.

Table 4: Helpfulness of Future Opportunities

Future Opportunity	% Who Selected
Website/networking	88.3%
Tools & resources	85.7%
Another gathering	81.8%
Webinars	58.4%
Other	22.1%

Suggestions for improving the workshop/event covered a number of issues, including:

- Group breakouts, discussions, or sharing time by grade level (and possibly by area of computer science, i.e., programs taught or computer science vs. applications)
- More time to attend all breakouts, for discussion, for networking, and to attend GHC
- Online/social networking both before and after event so that participants could contact one another
- Logistical issues with the conference being spread out, especially with the shuttle

4.1.4 Conclusions of the On-Site Evaluation

These data from the on-site evaluation indicate that the workshop was well received by participants and that the overall goals of the event were met. As one respondent commented: *"This was a fabulous opportunity—thank you! I go back to my teaching job energized and excited about working to make courses accessible to more girls and under-represented groups."*

4.2 Results of the Long-Term Evaluation

The external evaluator performed a follow up survey with workshop attendees in December. Rockman et al. found that the workshop had positively impacted the teaching practice of participating teachers. Qualitative data from the follow up survey, according to Rockman, were consistent with the positive ratings of the workshop. Upon reflection, 97.2% of teachers (n=36) stated that the workshop was of value to them. When asked to describe what was most valuable, respondents commented on (1) the ability to share and connect with colleagues, (2) gaining ideas and insights for their teaching practice, and (3) feeling energized about what they do. Open-ended responses in these categories included:

"Ability to meet and talk to other CS teachers from around the country. Refreshing new ideas for classroom and school. Invigorating atmosphere."

"Any opportunity to network, share, and collaborate with others in the same field is beneficial to our individual growth and knowledge."

"I am a Native [American?] woman from a small community and I hate to say, we are second class in Indian country but with the knowledge of computing we are a force in moving our people in the high tech world."

"I live in a small, remote area where students are not exposed to a lot of technology related experiences. The workshop helped me be better informed and prepared to relate more opportunities available for the students."

"The workshop renewed my interest and inspired me to get back into teaching programming. I see that a lot of high school students are taking programming classes and are doing well with it."

"It was incredibly inspiring to be around a group of women who were involved in computing careers and being successful. It was also helpful to talk to other teachers who had similar problems/situation and to find ways of resolving these issues in a positive way."

"The workshop has stimulated and motivated me to provide engaging lessons that can help women and minorities choose careers in computing."

What They Learned

To obtain a better picture of how the Town Hall and workshop affected the teachers who attended, the follow up survey asked respondents to describe something they learned that influenced their thinking. With respect to the Town Hall, teachers commented on the struggle computer science programs face, particularly at the district level, and how they often feel isolated:

"CS teacher throughout the nation are having similar frustration in getting CS accepted as a core subject within the state/districts."

"It seems we are all struggling with the same issues of teaching computer science courses and getting support."

"Most Computer Science teachers feel isolated. The course content varies widely from district to district, and state to state. Without a cohesive national effort to define just what a computer science class is and is not we will continue to swim upstream alone."

Others, though, were inspired by the ability to share and connect with others as well as the stories of women who struggled in the field:

"The most lasting impression made upon me was during the social hour, when I spoke to many young women about their personal experiences fighting gender discrimination as they studied computer science."

"There were so many women that it inspired me. When I got into CAD 35 years ago women were rare and I felt I had no one to talk to about some of the issues I encountered."

While the Town Hall brought up issues of common concern, the workshop left teachers energized with resources and readiness to take action in their districts and with their students, particularly girls:

"Boy is this an exciting field. We are a long way from the socially inept nerds coding in the back room and we need to do a better job of communicating what CS is to all segments of the population."

"I had no idea that a new AP course was being written to help the issue of minority/females not taking the AP course. I am energized by knowing that we have so much to look forward to and we are getting backing from NSF and ACM."

"Really enjoyed seeing how baby toys can demonstrate computing concepts and the culturally sensitive computing sites."

*"The idea of connecting middle- and high school-age children with college-age young women to see firsthand that computer science isn't a field limited to men. I also *loved* the teaching with manipulatives workshop. Using tools such as Alice to reach out to all students was also a key insight."*

"The introduction to CSTA's Exploring Computer Science curriculum is what I have been looking for to attract more underrepresented students into computer science. I have proposed the course to our district and it is in the approval process."

"The workshop was terrific! The discussion of new directions for the AP course really led me to think about the current course, how we teach it, and how I could change it to make it better and more attractive to underrepresented students."

"There are many opportunities for women and we need to help our young girls know about the opportunities; especially those girls who do not have examples of women in computing in their families or those they associate with."

Implementation Outcomes

Immediately following the workshop, participants indicated that they planned to use a variety of these strategies, including using new tools in their classroom, breaking stereotypes in their approach to teaching, reaching out to more diverse student groups, and networking with peers and local organizations.

The most difficult part of any social change initiative is the transformation of knowledge into action. The follow-up survey provided indicators of whether and how participants actually had implemented these takeaways when they returned to their classrooms, the daily struggles they faced, and lack of resources they experienced. In the follow up survey, 91.7% of the 36 respondents had implemented tools or resources gleaned from the workshop and 80.6% felt they had gained and implemented useful strategies for engaging diverse students in their teaching practices. Similar to what the teachers had planned, respondents indicated they had used a variety of strategies and made changes to their curricula, including: reaching out to girls, creating opportunities for success, making assignments "relevant" to students, and incorporating collaboration.

1. Curriculum Change for Greater Diversity

Some teachers are focused on making their CS courses more engaging to a broad audience of students:

"I have started the difficult process of attempting to change how we approach our curriculum in CS, as I realize that hitting new students with "public static void main" in a text editor on the first day is hardly engaging."

"I've started using Alice to reinforce various concepts in my classes, and we are in discussions about adding a trimester course entitled 'storytelling with animation' in order to entice a wider audience to try CS."

"I have implemented technology lessons that incorporate research on things teens appreciate (technology, meaning of names, holidays)."

2. Breaking Stereotypes for Greater Diversity

Others have started focusing on breaking stereotypes specific to girls and underrepresented minorities:

"I have tried to break the stereotypes of women and technology. My classes are mostly male so I have tried to integrate more assignments with blended groups."

"I do not have a diverse group of students to draw from; however, I am trying to encourage more girls to take my courses using the knowledge I gained about the opportunities available."

"Mixing of groups, lessons that are non-gender specific—more toward a business aspect. In other words—boys don't do assignments that have to do with sports and computer games and girls don't do assignments that are more 'feminine.' The students tend to gravitate to this and I have tried to make it more 'gender neutral' so they can see the importance of the skill, not which gender is doing the work."

3. Teacher Advocacy for Computer Science

Some teachers were also sharing with each other and reaching out to administrators and district-level personnel to discuss new courses and the importance of CS, including the following examples:

"I created a wiki for my teachers so that they can access online resources and activities for their students."

"I teach high school. I have submitted a proposal to offer a middle school robotics camp this summer to get the tools in the hands of the kids while they're still young and interested in exploring."

"My main focus is to increase administrators and counselors appreciation of computer programming's importance. Also, to make the class more enjoyable for students by using Alice and other 'quick results' tools such as Greenfoot."

Of the three respondents who had not implemented strategies they had learned at the workshop, one had approached the administration about adding a CS course, one felt the topic was not related to his/her subject, and the third commented:

"Well, I teach CAD and there were no specific resources for CAD. However, my spirits were raised seeing so many women involved. I also was stunned to discover that some companies acknowledged that women are better at gathering information and are key in software development. I found this to be true in my own experience. I developed information gathering forms that allowed me to give clients a better product. I use his information in the classroom with the girls when they express a feeling that CAD oriented industries are not for them."

4. Increased Community

Another goal of the Town Hall and workshop was to create a community of teachers. Of the 36 teachers who responded to the follow up survey, 41.7% indicated that they had interacted with other participants since the event. These educators reported sharing ideas, information, and lesson plans via email, Facebook, or Twitter.

CONCLUSIONS AND RECOMMENDATIONS

5.0 A Model for Systemic Change

This initiative has strengthened our knowledge of teacher challenges at the K-12 level in computer science and the intractable barriers they face in their efforts to increase the engagement and participation of students from underrepresented populations. Perhaps the most important takeaway of this endeavor is that the two events detailed in this report have given rise to and facilitated a cross-sector dialogue that has led to key strategies and essential partnerships that can transcend institutional boundaries.

A cross-sectoral approach to change in K-12 computer science education is needed. Indeed, most impactful social change initiatives involve cross-sector partnerships—as one author puts it, "the world's problems do not neatly apportion themselves between the private, nonprofit, and public sectors" (Kramer and Kania, 2006). Too often, in discussing educational reform, a top-down approach has been the norm, with both private and government policy experts pushing change on K-12 educators without engaging them in the design of the change model. The voices of the teachers (on whom these changes are pushed) are silenced and, as a result, efforts to implement systemic and sustained change prove ineffective. The model for cross-sector intervention is shown in Figure 4.

This partnership between CSTA and ABI has the potential for impact, not just through these two events, but as a critical vehicle to bridge this gap between teachers and public and private partners. We have built a model of cross-sector information and strategy sharing where the teachers are equal partners in the design and implementation of change initiatives, are the acknowledged experts on effective change strategies for their classrooms, and where all of the potential stakeholders can provide a key role in the formulation, dissemination, and ongoing support of these successful strategies and best practices. A critical step in expanding these experiences, therefore, is establishing and disseminating the opportunities for partnering by various constituencies.

5.1 The Role of Academia and Government

Academic institutions have a critical opportunity to engage with K-12 CS teachers in addressing key equity issues in computer science education. Universities have access to the latest developments in the discipline of computer science, both from a research perspective and a practitioner's point of view. Many post-secondary faculty are also aware of equity challenges and are actively involved in adapting their curriculum and their pedagogy for greater representation. Post-secondary faculty are also uniquely suited to provide K-12 educators with information regarding what constitutes a well prepared incoming computer science student and how K-12 can best prepare a diverse set of students to succeed in computer science at the college level. For this dialogue to prove effective, however, the discussion must extend beyond traditional exchanges with regard to grade point averages and prerequisite courses. It must include considerations of what characteristics will best prepare students to be successful academically as well as remain in computer science, even if they are a minority.

Because post-secondary faculty and departments are also often better resources than their K-12 counterparts, they also have a responsibility to mentor and support K-12 teachers in their efforts to implement the changes necessary to ensure preparedness of a greater proportion of girls and underrepresented minorities. For instance, post secondary faculty can directly mentor classroom teachers. Undergraduate and graduate students can actively engage with K-12 schools in their communities, acting as much-needed role models and mentors to students, as well as helping bring the latest computational knowledge into the K-12 classroom. One successful example of such collaboration is the Java Engagement for Teacher Training (JETT) and Teacher Enrichment in Computer Science (TECS) programs led by CSTA in collaboration with universities and colleges across the United States. Similarly, governmental institutions focused on technology such as NASA, the National Labs, the Department of Defense and the National Security Agency, can significantly engage with K-12 teachers in the classroom.

In addition, individuals and organizations from all academic levels can work together to better inform educational policy makers within school districts and at the state and federal level about the importance of providing all students with access to rigorous computer science courses in high school. The ACM Educational Policy Committee, for example, has experienced considerable recent success through its efforts to actively engage government entities, policy makers, and K-12 administrators in critical discussions about policy interventions needed at the national and state levels. Steps such as these help address the prevalent feeling of not being heard by policy makers at the local and state levels voiced by participating teachers in the Town Hall and workshop.

5.2 The Role of Industry

The private sector, and in particular the high-technology industry, has expressed concern about the incoming pipeline of technical talent—especially when it comes to diversity. Many companies have active programs disseminating their technology to schools and multiple outreach programs to informal education efforts such as after-school programs and summer camps for girls. However, few of these efforts focus on formal education and engage K-12 teachers. The Anita Borg Institute for Women and Technology, for example, has a very large constituency of technical women in industry who want to give back to the next generation, yet struggle to find the points of connection with K-12 formal education.

There is a critical opportunity to rectify this situation. While the financial and technology resources of industry can play an essential role in supporting K-12 CS teacher needs, our model places an emphasis on going beyond financial support and the provision of software to involve active knowledge exchange and participation. Industry representatives can engage with K-12 teachers to provide an accurate and up-to-date picture of the computational thinking skills that a diverse body of students needs to engage successfully in the workforce. In addition, industry representatives can provide critical support for the argument that success in today's global knowledge economy requires high-level analytical and collaboration skills and the ability to manage complex information—skills that are not always emphasized by current K-12 efforts that remain focused on learning to use software applications (point-and-click education). Industry also has the opportunity to engage directly in the classroom by providing technical employees, especially women and underrepresented technologists, who can act as role models and mentors. Furthermore, these industry employees can convey the excitement and impact of working with cutting-edge technology and actively dispel the stereotypical beliefs held by students, parents, and school administrators about a technology career.

Finally, industry can play a major role in advocating with educational policy makers to ensure that every student has access to a rigorous computer science course in high school. As school, district, state, and federal policy makers struggle to make decisions about what students need to know and how to provide equitable access in a time of diminishing resources, industry leaders can provide a key perspective on the role computer science plays in the national economy and in all scientific innovation. Industry leaders can also communicate the critical importance of providing all students the opportunity to engage in and explore this field in meaningful ways in the K-12 curriculum.

5.3 The Role of K-12 Teachers

Teachers are in desperate need of resources and support to increase equity in their classrooms, yet they have limited funds and packed schedules with limited professional development and networking opportunities. This situation makes outreach across sectors inherently difficult. Access to events such as the Hopper Town Hall and K–12 Equity Workshop provide a key mechanism for illuminating the barriers and sharing the solutions among key stakeholders.

There is no doubt that post-secondary educators and industry are actively engaged in supporting computing equity in schools and the proof is in the hundreds of thousands of dollars that the major industry players spend annually on educational projects and initiatives. But even the most generous players wonder if their contributions are achieving as much as they could or should. Computer science teachers are at the front line of computer science education, struggling to achieve exemplary results often with exceedingly minimal resources and support. They know their classrooms and their students and can provide critical feedback to academia and industry on how best to use the available resources to achieve the greatest educational results. Teachers are critical actors in disseminating successful models of partnerships and solutions within their communities. With improved support, they can do a better job of dispelling the myths associated with computer science and strengthening support from colleagues and school administrators.

Finally, industry and academia can benefit tremendously from working directly with the teachers and students, collecting precious information about the incoming generation of students and adapting their practices to create inclusive environments for the next generation of women and minority computer science students and workers. For instance, industry leaders are wondering how to adapt to the needs of the "millennial" generation, often feeling unprepared to incorporate their values into work environments. Actively engaging K-12 teachers and students would provide critical insight into their values and needs.

Looking to the future, the follow-up survey respondents indicated that they would continue to enhance their teaching with the tools and resources they had gained, work to develop new courses and programs, to train fellow teachers, and focus recruiting efforts on girls. One respondent laid out a vision for the future:

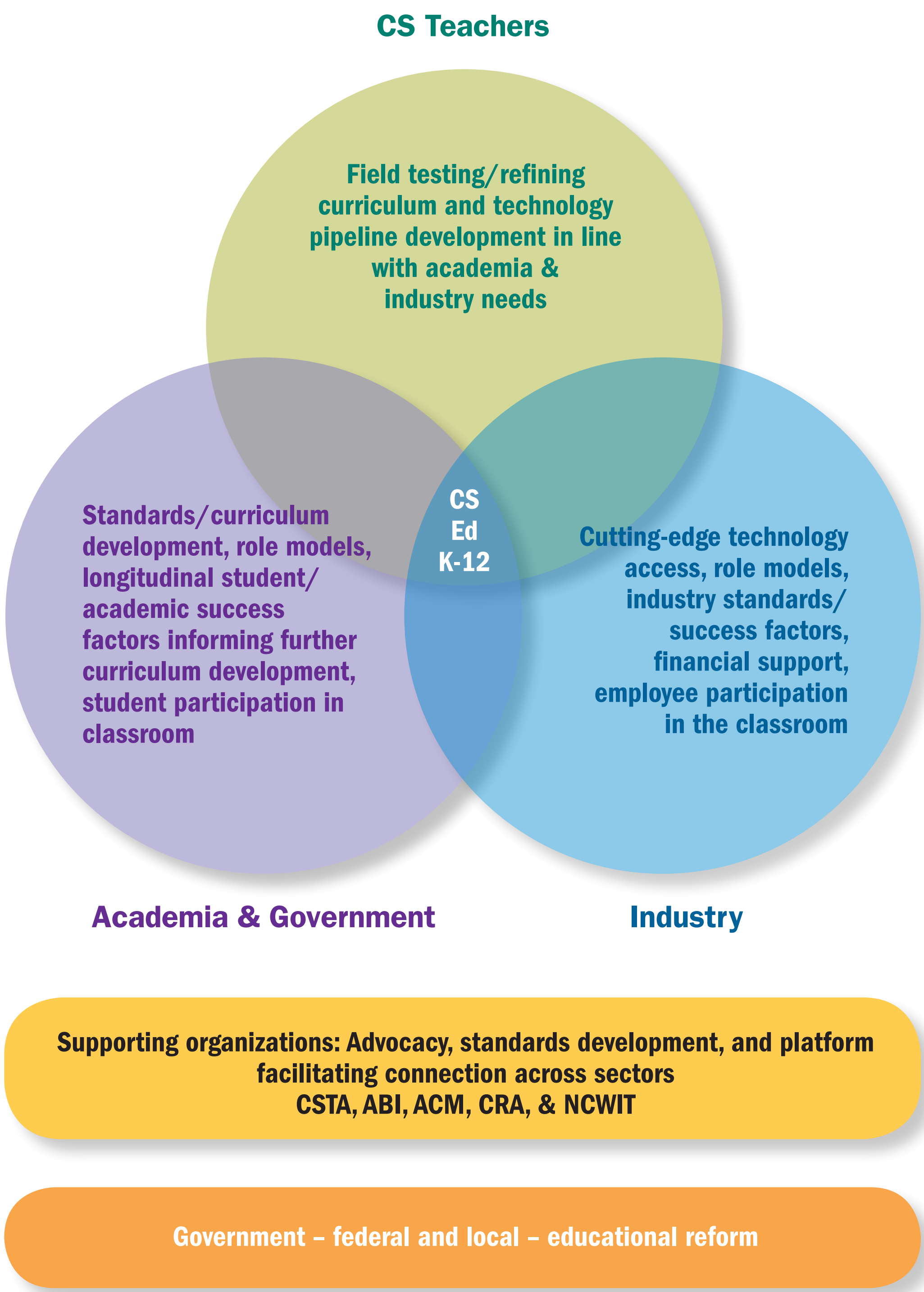
"I would love to organize a state-level K-12 Computing Consortium that would involve all the stake holders: teachers, college professors, state education administrators, students, parents, etc. The goal would be to get everyone on the same page in terms of where the state is going with CS education at the K-12 level, and then implement a strategy for getting there. The NSF has laid down the gauntlet for 10,000 teachers by 2015. At the state level, we need to get our share. This involves, not only deciding on a curriculum, but also training teachers and creating a groundswell of demand at the parent/student level to fill the courses once they are available. It also involves convincing college administrators that CS on a transcript is desirable (and hopefully one day required)…This is heavy on the 'plans' and light on the 'implementation.' Once again that 24-hour day gets in the way."

5.4 The Role of Supporting Organizations

Nonprofit organizations like ABI and CSTA are working synergistically to create platforms where critical connections can occur. CSTA provides much-needed curriculum development and standards, knowledge, and advocacy at the federal and state levels. In addition, CSTA provides community for the teachers and has been actively engaged in fostering academic and K-12 teacher partnerships. Under the guise of ACM—a professional organization reaching more than 96,500 (as of December 2009) computer professionals across academia and industry—CSTA is uniquely placed to establish these cross-sector connections. Through its Leadership Cohort program, CSTA also extends the dialog to policy makers at the state and national levels, actively advocating the establishment of CS as a core discipline in K-12 and creating key opportunities for building learning communities through CSTA's local chapters

Specifically focused on equity issues, the Anita Borg Institute for Women and Technology works to increase the representation of women in technical fields and reaches a constituency of 11,000 technical women and men in industry, academia, and government. The Grace Hopper Celebration of Women in Computing, co-hosted by ACM and ABI, is a national platform where industry, academia, and government meet to further increase the representation of women in computing. K-12 had traditionally been missing from that platform and this partnership involving CSTA, the University of Arizona, and ABI has shown the potential of the Grace Hopper

Figure 4: Cross-Sector Partnerships to Enhance K-12 Computer Science Education



Celebration to support the establishment of those cross-sector connections to accelerate the recruitment and retention of technical women and underrepresented minorities at the K-12 level.

5.6 A Beginning Rather Than an End

The community focus on K–12 computer science education created at the 2009 Grace Hopper event was a fruitful starting place. The community of practitioners revealed daily struggles to provide opportunities for their students in an environment that neither understands nor supports the key role of computer science in the twenty-first century skill set of every educated person. Post-secondary educators with a commitment to equity have learned a great deal about the continuous struggles, but also the ingenious strategies classroom teachers devise. And industry leaders have learned about resource and skill gaps they might never had known existed without the opportunity to meet as a community in these key discussions.

The 2009 Hopper K-12 Town Hall and K-12 Teachers Equity Workshop allowed us to examine critical issues and discover solutions that have the potential to involve all stakeholders in creating profound and sustainable change. Toward this end, we have constructed the following solutions table to help change agents better identify the issues and actions they can take.

These 2009 activities have also engendered new conversations, understandings, relationships, partnerships, and plans. Here are just a few of the ways in which this work is being carried forward:

- ABI has become an official partner with CSTA, Google, and Microsoft Research in CSTA's annual Computer Science & Information Technology Symposium. On July 13, 2010, 200 computer science and information technology teachers will attend a full day of relevant and engaging professional development at Google Headquarters in Mountain View, CA.
- Plans are now underway for two full days of K-12 events at the 2010 GHC in Atlanta, GA. These events will include talks, presentations, and events focusing on issues in K-12 computer science education for the entire community of stakeholders as well as a one-day workshop specifically for K-12 teachers.

The 2009 K-12 Town Hall and K-12 Teachers Equity Workshop represent the beginning of conversations, community building, and partnerships that embody enormous potential for achieving real change in K-12 computer science education equity. This potential, however, can only be met if this is understood to be just a first step in the change process. More conversations need to be had, more strategies shared, and more key partnerships formed. And CSTA and ABI are committed to doing their part to ensure this happens. As a next step, CSTA and ABI are repeating the workshop at GHC in 2010. The program will be designed to support a greater number of teachers and to increase cross-sector participation and dialogue. But the success of these next events will also depend upon the willingness of our entire community to step up and play its part. The teachers need to find time to attend professional development events. Post-secondary educators have to commit time and energy to understanding the realities of teaching and learning in K–12. They must also focus their efforts on developing critical resources that truly support learning and engagement. In addition, key sponsors must provide funding to enable these community and learning events and follow-through on their commitment to building and sustaining real partnerships with K–12. Only as a community can we hope to address the critical need for equitable computer science education. There has never been a better time.

Table 5: Solutions Matrix

Critical Issue	Teachers	Administrators	Policy Makers	Faculty	Organizations	Industry
	Stakeholder Solutions					
Too few rigorous computer science courses for students.	Adopt national curriculum standards.	Provide access to rigorous CS courses in every school. Increase funding for CS programs.	Adopt recognized CS curriculum standards. Allow rigorous CS courses to count toward math/ science graduation requirements. Adopt relevant teacher certification standards. Support differential pay scales to attract/ retain teachers.	Provide in-service and professional development programs for CS teachers. Mentor local teachers and students.	Provide professional development opportunities for teachers. Create and disseminate materials on careers in CS. Help policy makers understand the link between K-12 CS education, professional opportunity, and national economic priorities.	Fund professional development opportunities for teachers. Create and disseminate materials on careers in CS. Advocate with policy makers on behalf of K-12 computer science education.
Lack of dedicated resources.	Clearly communicate hardware and software needs to administrators.	Ensure that CS labs are up-to-date. Eliminate unnecessary bureaucracy preventing access to tools and resources.	Provide adequate technical support at the district level and school level.	Provide access to university resources.	Help teachers identify possible funding sources for materials and programs.	Provide funding and resources for hardware and software.
Underrepre-sentation of women and minority students	Create welcoming classrooms. Adopt pedagogies that focus on active engagement and real world applications. Use culturally-centered assignments. Mentor students to build self confidence. Build relationships with teachers in other subjects to help in recruitment.	Ensure that timetable scheduling allows students to access rigorous CS courses. Ensure that guidance counselors are encouraging girls and minority students to take rigorous CS courses. Support CS courses even if class sizes are small.	Support access to rigorous CS education as a social justice issue.	Support access to rigorous CS education as a social justice issue.	Create and disseminate materials on careers in CS specially targeted for under-represented student populations. Help policy makers understand that access to CS education is a social justice issue.	Create and disseminate materials on careers in CS specially targeted for under-represented student populations. Help policy makers understand that access to CS education is a social justice issue.
Lack of student engagement	Actively recruit students from diverse backgrounds to CS courses. Dispel myths about CS as a career. Inform students about educational pathways and career opportunities. Bring in interesting speakers (especially near-peers). Provide open house events for students and parents.	Ensure guidance counselors are aware of and advise students on appropriate educational pathways and career opportunities.		Dispel myths and misconceptions about CS as a discipline or a future career.	Set up ongoing outreach programs with K-12 schools. Support road show programs that engage students in outreach. Provide relevant career information for students, parents, and guidance counselors. Dispel myths and misconceptions about CS as a discipline or a future career.	Speak to key stakeholder groups (students, administrators, parents, policy makers) about opportunities in the high tech field. Provide summer internships for students.
Teachers as professionals	Form personal learning communities. Join professional educational associations. Develop leadership and advocacy skills. Build partnerships across educational levels and with business/industry.	Support teacher participation in learning communities and professional associations.	Support teacher participation in learning communities and professional associations.	Support professional associations for CS teachers	Provide leadership and advocacy skills development opportunities for teachers. Provide opportunities for teachers to meet as colleagues.	Support professional associations for CS teachers. Provide opportunities for teachers to meet as colleagues. Provide summer internships for teachers.

References

ACM K–12 Task Force. (2005). ACM K–12 Task Force Curriculum Survey Results. Retrieved December 22, 2005, from http://csta.acm.org/Research/sub/TuckerSurveyResults.html

Bloom, B., Englehart, M. Furst, E., Hill, W., & Krathwohl, D. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. New York, Toronto: Longmans, Green.

Bureau of Labor Statistics Occupational Outlook, 2009.

Camp, T. (1997). The Incredible Shrinking Pipeline. *Communications of the ACM*, 40(10), 103 110.

Camp, T., Miller, K., and Davies, V. (1999) "The Incredible Shrinking Pipeline Unlikely to Reverse." *Association for Computing Machinery Committee on Women in Computing Report*, Retrieved March 1, 2009 from http://inside.mines.edu/fs_home/tcamp/

Carnevale, P. and Desrochers, Donna M. (2003). The Missing Middle: Aligning Education and the Knowledge Economy, Educational Testing Service,April 2002.

College Board (2009).

Commission for Professionals in Science and Technology. (2006). *Professional Women and Minorities: A Total Human Resources Data Compendium* (16th Edition). Washington, DC: CPST.

Computer Science Teachers Association. (2005). Results of the national secondary computer science survey. Retrieved October 16, 2005 from http://csta.acm.org/Research/sub/ CSTANationalSurvey2004.html

Computer Science Teachers Association (2009). The State of Secondary Level Computer Science Education in the United States. Presentation. Retrieved January 10, 2010 from http://www.csta.acm.org/Communications/sub/DocsPresentationFiles/StephensonNewNZPres.pdf

Council of Chief State School Officers (CCSSO). (2004). Immigrant Students and Secondary School Reform: Compendium of Best Practices. Retrieved January 11, 2010 from http://www.ccsso.org/content/pdfs/BestPractices.pdf.

Jackson, S.A. (2004).The Perfect Storm: A Weather Forecast. Address at the American Association for the Advancement of Science Annual Meeting, Seattle, Saturday February 14, 2004. Retrieved March 21, 2008, from: http://www.rpi.edu/president/speeches/ps021404-perfectstorm.html

Kramer, M. and Kania, J. (2006). Changing the Game: Leading Corporations' Switch from Defense to Offense in Solving Global Problems. *Stanford Social Innovation Review*, Spring 2006.

Klawe, M., Whitney, T. and Simard, C. 2009. Women in Computing, Take 2. Communications of the ACM, Feb. 2009.

Margolis, J., Goode, J., Jellison Holme, J., & Nao, K. (2008). *Stuck in the shallow end: Education, race, and computing*. Cambridge: MIT Press.

National Academies of Engineering. (2007). Rising above the Gathering Storm: *Energizing and Employing America for a Brighter Economic Future. Retrieved October 2009 from* http://www.nap.edu/html/11463/11463_revisions.pdf; Business Higher Education Forum. (2003). Retrieved January 7 from http://www.bhef.com/publications/documents/building_nation_03.pdf.

National Science Board. (2008). *Science and Engineering Indicators 2008* (NSB 08-01), Arlington, VA; Retrieved March 1, 2009 from www.nsf.gov/statistics/seind08/

National Science Foundation. (2007). Higher Education Research Institute, University of California at Los Angeles, *Survey of the American Freshman, special tabulations* (Los Angeles, CA, 2007).

National Science Foundation, Division of Science Resources Statistics, Survey of Graduate and Postdoctoral Students in Science and Engineering, 1996 and 2006. Retrieved March 1, 2009 from http://www.nsf.gov/statistics/infbrief/nsf08302/

National Science Foundation, Division of Science Resources Statistics. (2008). *Women, Minorities, and Persons with Disabilities in Science and Engineering.* Arlington, VA. Retrieved March 1, 2009 from www.nsf.gov/statistics/wmpd/.

National Science Foundation, Division of Science Resources Statistics. (2009). *Women, Minorities, and Persons with Disabilities in Science and Engineering* (NSF 07-315). Arlington, VA. Retrieved March 1, 2009 from www.nsf.gov/statistics/wmpd/.

Stephenson, C. (2006). Addressing key concerns in K-12 computer science education. Presentation to Faculty Colloquium at Carnegie Mellon University, November 7, 2006. Retrieved on March 6, 2009 http://www.csta.acm.org/Communications/sub/DocsPresentationFiles/CMUPres06.pdf

U.S. Census Bureau (2008*). National Population Projections*. Retrieved March 1, 2009 from http://www.census.gov/population/www/projections/downloadablefiles.html

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