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Choosing Outreach Strategies to Increase Interest in IT Careers

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Training and Resources for Assembling Interactive Learning Systems

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Introduction

Even as American youth are wholeheartedly embracing information technology (IT) for communication and entertainment, many signs indicate that they are losing interest in understanding and advancing the computer technology that drives it. The industries that rely on an IT-savvy workforce can and must play an active role in reversing this trend. This white paper analyzes model outreach programs and offers a framework for helping a company identify the most appropriate strategies for helping reinvigorate interest in IT.

Some History

In 1968, a 13-year-old enrolled in the Hewlett-Packard (HP) Company's "Explorer's Club." There, engineers wowed him with a new class of "calculator" that ran programs stored on magnetic cards. A year later, the teen landed a summer job at HP, where he befriended another young technology enthusiast and Explorer's Club member. Eight years later, on April 1, 1976, the two launched a company that revolutionized personal computing. Their names were Steve Jobs and Steve Wozniak, and the company, of course, was Apple Computer.

What inspired Jobs and Wozniak 30 years ago to pursue careers in computing? History suggests a range of factors. The two were fortunate to grow up at time when near-state-of-the-art computer technology had become accessible to the hobbyist. They developed their electronics hobby through informal interactions with peers and mentors. Especially relevant for this white paper is that both learned about electronics through connections with industry: while in high school, Jobs attended after-school lectures at the nearby HP plant, and Wozniak learned mathematics and electronics from his father, a Lockheed engineer. Clearly, the two saw something powerful in electronics and computers that gave them a thirst for knowledge and the vision to create something new that would change the world.

Within 7 years of the founding of Apple, computer science (CS) would emerge from virtual obscurity to be the intended major of nearly 5% of freshman undergraduate students.

Fast Forward to the Present

Since peaking in the early 1980s, the number of CS majors in American universities has decreased by 70%, and a 2004 survey that differentiated between genders found that women's interest in CS had dropped to its lowest point since 1971 when data were first collected.[1] The percentage of freshman students indicating computer science as their probable major has plummeted to just 1.1%[2]. A 2005 survey reveals that high-aptitude high school students have little concept of what CS majors learn.[3] If students have a picture of CS, it is rarely flattering: stereotypes such as that of the lone, late-night worker bias students' opinions. In the same survey, respondents worried that a CS career would require sitting in front of a computer all day with little social interaction. In many high schools, CS teachers, even those teaching advanced

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[1] Vegso, J. (2005, May 2005). Interest in CS as a Major Drops Among Incoming Freshmen. Computing Research News, Vol. 17/No. 3. Available at http://www.cra.org/CRN/articles/may05/vegso. Last accessed March 6, 2007.

[2] Vegso, J. (2007). Low Interest in CS and CE Among Incoming Freshmen. Computing Research Association Bulletin, February 6, 2007. Available at http://www.cra.org/wp/index.php?p=104. Last accessed March 6, 2007.

[3] Carter, L. (2006). *Why students with an apparent aptitude for computer science don't choose to major in computer science.* Paper presented at the 37th Special Interest Group for Computer Science Education (SIGCSE) Technical Symposium on Computer Science Education.

placement (AP) CS, are not specifically trained in a computing discipline but instead may be mathematics or science teachers lacking grounding in CS foundations.[4]

Furthermore, interest in computing has stagnated not just within the specific discipline of CS, but also in biology, physics, and other sciences. Science practitioners are complaining that students are not receiving training in computing for these sciences and do not even appreciate the need for computing in the disciplines, even as the scientific profession is being transformed by computers and the emerging Cyberinfrastructure.[5]

Summary of Recent Reports and Recommendations

The indications above of declining interest in IT studies, among other signs, have raised a serious national concern. Presidential committees and industry reports argue that American competitiveness and our quality of life are seriously threatened by declining rates of enrollment and graduation in IT and the related fields of engineering and science. A minority opinion is that we are merely experiencing a low point in periodic cycle of IT interest. This white paper does not take sides in this debate; instead, we identify practical options for remedial actions should a company decide that these trends indeed pose a significant threat to the health of its business. To help make this decision, we recommend a thorough review of several recent reports. Even if the need for workforce development is already clear to a particular company, these reports may offer further justification—at the level of national interest—to help strengthen the case to upper management for significant investments in outreach programs. Below we summarize key reports. The appendix provides more thorough review of each report.

The Debate over American Competitiveness

Two major studies, one by the National Academies[6] and the other by the U.S. Chamber of Commerce,[7] have expressed deep concern that the United States is falling behind other nations in producing college graduates in science and engineering. The National Academies' report indicated that 50% of all undergraduates in China receive their degrees in natural science or engineering, whereas in the United States the corresponding figure is 15% (p. ES-10); similarly, the Chamber of Commerce's report noted that by 2010 more than 90% of all scientists and engineers in the world will be living in Asia. The National Academies concluded, "[T]he committee is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength." A third study by Microsoft, which focused specifically on CS education,[8] cited research finding that CS enrollment has declined by 30% in the last few years and forecast ominous implications for American competitiveness in virtually all scientific and technological fields, given that so much research depends on computing. The three reports made broadly similar recommendations: increase federal investment in research, recruit additional teachers, offer more scholarships, revamp existing curricula, strengthen intellectual property laws, attract women and minorities with special programs, attract foreign talent with visa and immigration reforms, provide tax

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[4] Stephenson, C. (2000). *A report on high school computer science education in five U.S. states.* Retrieved March 7, 2007 from http://www.holtsoft.com/chris/HSSurveyArt.pdf

[5] Microsoft. (2006). *Towards 2020 science.* Retrieved March 7, 2007 from http://research.microsoft.com/towards2020science

[6] National Academies. (2006) *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Retrieved March 6, 2007 from http://www.nap.edu/books/0309100399/html

[7] U.S. Chamber of Commerce. (2005). *Tapping America's potential: The Education for Innovation Initiative*. Retrieved March 6, 2007 from http://www.uschamber.com/publications/reports/050727_tap.htm

[8] Microsoft. (2006). *The future of information technology*. Retrieved March 6, 2007 from http://research.microsoft.com/Workshops/FS2006/papers/TheFutureofInformationTechnology.pdf

incentives for private research, and counter negative impressions of life in technical fields with public-relations campaigns.

On the other hand, two studies have argued that perceptions of U.S. decline are exaggerated and perhaps even motivated by a hidden corporate agenda. Duke University[9] compared engineering curricula in China, India, and the United States, and discovered that the word "engineer" signifies different levels of scientific knowledge and educational achievement in each country. The study maintained that once curricula are strictly compared, the United States still produces more highly qualified engineers *per capita* than any other country. In a similar vein, Norman Matloff,[10] a University of California at Davis CS professor, has argued that industry claims of a labor shortage are specious. Matloff points to statistics showing an industry preference for entry-level, low-wage programmers fresh out of school or from abroad. "When the industry claims a shortage of programmers," Matloff writes, "what they mean is a shortage of cheap programmers." He singles out the H1-B visa program for particular criticism, arguing that it amounts to exploitation of foreign labor. His report suggests that if American businesses retrained older employees and hired new employees for intellectual ability, rather than for knowledge of specific programming languages, they would have no shortage of programming talent.

What Is a Company to Do?

If a company is worried about changes in the U.S. IT workforce, can it do something now to improve the human resource environment in the not-too-distant future? From our analysis of outreach programs to date, the answer is "yes." Furthermore, although the recommendations of the Chamber of Commerce, National Academies, and Microsoft are grand in scope, small companies can also make a difference. The rest of this white paper seeks to help companies identify the most appropriate initiative for their needs and capabilities. First, we present a four-dimensional framework for assessing outreach opportunities. Then, we analyze a range of initiatives using that framework.

Four Dimensions of the Outreach Program Decision Space

Through a literature review,[11] Web-based research, and interviews, we have identified four key dimensions that differentiate outreach programs aimed at improving the future IT workforce.

Cost. What is the material and personnel cost of the program? Are employees given release time to support the program? Does the company already have the resource required (e.g., employees with the correct expertise or diversity status)?

The cost ranges from **low** to **high**.

Impact. What end result is desired: recruiting qualified employees into the company, interesting youth in IT careers, or generating goodwill for the company?

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[9] Duke University. (2005). *Framing the engineering outsourcing debate: Placing the United States on a level playing field with India and China*. Retrieved March 6, 2007 from http://memp.pratt.duke.edu/downloads/duke_outsourcing_2005.pdf

[10] Matloff, N. (2002). *Debunking the myth of a desperate software labor shortage*. Retrieved March 6, 2007 from http://heather.cs.ucdavis.edu/itaa.real.html

[11] We found that the conference proceedings published by the Association for Computing Machinery's (ACM's) SIGCSE (http://sigcse.org) cited the most published reports of outreach programs with academic connections.

The impact ranges from **direct**, in which a company can use an outreach program to evaluate and recruit a potential employee, to **indirect**, in which a company invests in activities that promote interest in science and mathematics.

Commitment. What is required of the company at the outset of the outreach program and over time? To what degree must the company be involved for the program to be a success? How intimate a relationship will the company have to maintain with an external partner? Is a longer term arrangement expected (e.g., for annual events)? Will pulling out of an initiative once it is set in motion result in dire consequences for the company?

Commitment ranges from **low** (e.g., when a company makes a donation to sponsor an event put on by another organization), to **high** (e.g., when a company partners with an academic institution to offer a specialized course of study that will produce more qualified employees).

Sustainability. What level of effort is required to keep the program running and successful? Self-sustaining programs do not require much effort (e.g., a multiyear scholarship program for CS students). In contrast, a national competition requires repeated investments in marketing, event planning, and recruitment of new participants.

Other Considerations

The four dimensions discussed above are the major factors to consider when adopting an outreach program. At the same time, other considerations—risk, breadth of impact, scale, and uncertainty—could be important when planning an outreach program. These other considerations are described below.

Risk cuts across all of the dimensions listed above. All commitments to outreach programs entail risk. The cost may prove to be too high, the impact may prove to be negligible, commitments may be made and then not kept, and the program may require too much effort to sustain.

Breadth of impact may be an important feature of an outreach program. Earlier, we cited reports that promote the creation of programs and policies at a national level. Such efforts will obviously have a greater breadth of impact than one company's outreach program. However, the impact of company outreach activities in the local community or a specialized program sponsored by the company (e.g., at a graduate school) can send qualified employees its way.

Scale may be a consideration at the outset of an outreach program if the nature of the outreach is intended to be national or global. A local science competition that scales to an international one could be effective outreach. When starting a program a company may not consider scale, but it may want to do so if a program developed for one location will work in another region where the company has a significant number of employees.

Uncertainty can be a concern for new programs or programs that depend on partners. No outreach program is guaranteed to work smoothly or to produce its intended result. Not all programs are evaluated for impact, and companies may experiment with different formats, contexts, or entirely new programs, all of which can affect certainty. Different companies' views on the degree of uncertainty they are willing to tolerate in an outreach program will vary. A company may want a flexible and fault-tolerant program because it wishes to scale it or to export it to other parts of the company. It may want to clearly understand to what it is committing in starting an outreach program. Finally, it may not wish to deal with the uncertainty that comes from encountering external factors that are beyond its control.

A Review of Prototypical Initiatives

To help companies decide on an outreach program, we recommend that they use the framework outlined above to analyze their options. To illustrate such an analysis and to provide the reader with exemplary outreach programs, we review a range of prototypical initiatives below.

Competitions/Science Fairs. Science, technology, engineering, and mathematics (STEM) competitions (e.g., robotics) and/or science fairs can provide good visibility for a company, and can be repeated annually. Like academies, workshops, and summer camps (which are discussed below), these competitions target specific content areas and skills. Competitions also allow greater flexibility in selecting desired contest participants such as varying the age groups or targeting minorities.

As an example, the US FIRST Robotics Competition (FRC)[12] is a prestigious international event where teams of high school students who have designed and built remote-controlled robots compete. Their robots participate in sports-like tournaments such as running through obstacle courses or shooting balls through hoops. By providing a meaningful context, setting, and adequate resources, the program promotes interest and skill development in robotics, and more generally in science, technology and engineering.

FRC is led by FIRST, a nonprofit organization; corporate sponsors provide support in the form of employee volunteer hours (e.g., mentorship of teams or event planning), financial sponsorship, and equipment donations. Companies could opt to stage similar competitions at a smaller scale (e.g., the local level). School-based science fairs, judged by employees, are simpler variations that would be easier to execute. Such fairs could be grown into regional activities that flow into state-level and national-level competitions.

Dimension	High	Medium	Low	Notes
Cost			✓	Cost of employee labor, materials and supplies.
Impact		✓		Indirect, although national competitions can showcase student talent in STEM areas.
Commitment	✓			Long-term is best to recruit participants; industry partnerships with schools are important.
Sustainability	✓			Easy to repeat every year.

[12] Retrieved March 5, 2007 from http://www.usfirst.org/

Workshops/Festivals. Companies and nonprofit agencies view workshops as a good opportunity to expose younger students to careers in IT and engineering and to build name recognition in the community. Teachers can be the major drivers for getting students to attend.

One long-standing and broad-scale event is the Expanding Your Horizons (EYH)[13] program for middle school- and high school-aged girls. Held on many school campuses or at companies, and staffed by women from academia and industry, girls are exposed to a variety of career and technical information in hour- or half-day-long activities. Another event is the Sally Ride Festival,[14] which targets girls and young women interested in science, mathematics, and engineering. EYH is staged as a local street fair with booths, food, and music; attendees engage in various hands-on activities and participate in talks and workshops given by local practitioners (e.g., engineers, veterinarians, astronomers) who provide information about their fields or practices, as well as offering guidance to parents and teachers about ways to support girls' interests in science and mathematics.

Dimension	High	Medium	Low	Notes
Cost			✓	Cost of employee labor, materials and supplies.
Impact			✓	Indirect, as are many programs that target K-12 students.
Commitment			✓	A workshop or festival can be viewed as a one-time event, although EYH programs are held yearly.
Sustainability	✓			Easy to repeat every year.

Workshops, festivals, and STEM competitions are low-risk and certain events. Getting them to scale nationwide can broaden their impact. The only possible risk involved is in recruiting sufficient participants.

[13]Retrieved March 5, 2007 from http://www.expandingyourhorizons.org/
[14]Retrieved March 5, 2007 from http://www.sallyridefestivals.com/

Mentoring/Job Shadowing. Mentoring and job shadowing can provide important career supports for young adults. At the post-secondary level, these programs are typically combined with a scholarship or fellowship program. Although these programs require more employee effort than the other programs described above, they have a concomitantly higher potential impact.

At the secondary level, Northrop Grummann's (NG's) Electronic Systems Division is reaching out to high school students through its Worthwhile to Help High School Youth (WORTHY) program. For one-half day each month, students gain first-hand, one-on-one experience at a real work site, where they observe the business and the professional life of practitioners. Furthermore, students benefit from enrichment activities and discussions on academic issues and career guidance.

Summer camps[15] are another venue for mentoring: Industries and nonprofit agencies view summer camps as good opportunities to expose younger students to careers in IT and engineering and to build company name recognition in the community. For example, IBM runs a summer camp for girls called EX.I.T.E (Exploring Interests in Technology and Engineering).[16] These week-long camps are for middle school girls and are held in more than 30 countries where IBM has a presence. IBM does not dictate the structure of the camps, which local employees organize.

Follow-on mentoring for EX.I.T.E campers is provided via a partnership with an eMentoring program called mentorplace.[17] This site is hosted by a nonprofit, EdReach, which IBM supports. Having an external partner host the site not only makes it more sustainable, but also allows the site to host content that looks different from that of the corporate site.

Dimension	High	Medium	Low	Notes
Cost		✓		Mainly the cost of employee labor.
Impact		✓		Somewhat indirect, although summer camps can focus on technical skills.
Commitment	✓			Long-term is best to establish the reputation of the program.
Sustainability		✓		Easy to sustain if employees volunteer and supplier schools are committed to sending students.

Mentoring and job shadowing introduce little uncertainty or risk, and provide a good means to involve local students in a company.

[15] These summer camps are not like the camps attended by elementary school students that provide summer childcare and enrichment activities. Rather, the "camps" target middle and high school students from underrepresented groups.
[16] Retrieved March 5, 2007 from http://www.ibm.com/ibm/ibmgives/grant/education/camp.shtml
[17] Retrieved March 5, 2007 from http://www.mentorplace.org/login.do

Curriculum Materials/Repositories. These programs provide a repository (often on the Web) of teaching materials or developer resources for students' and teachers' use. This approach is a relatively low-cost, low-maintenance channel for exposing students to the company, its culture, and its tools. Repositories collect content and skills in a way that is similar to an academy. Challenges for any type of Internet repository include building a sense of community around the resources that encourages their use and assuring additional contributions to the repository. Our brief review of several programs indicates that these issues remain challenges.

Sun Microsystems provides several examples of such repositories. Curriki[18] is a broad, open community containing open source curricula, education tools, and learning materials for those who write code; it also provides general education resources. For current and aspiring Sun developers, the Sun Developer Network Academic Developer Program[19]provides Web-based training, tools, blogs, free consultation with experts and other developers, and newsletters, among other offerings. The Education Commons[20] is a virtual community supporting users of Sun systems in academia. It includes forums, featured stories, webcasts, projects, and special interest groups.

Some outreach repositories provide in-house resources for employees who participate in volunteer activities. These resources range from simple lists of local organizations that need assistance to more comprehensive support materials for various activities such as working in classrooms and mentoring students. Organizing these in-house resources around a cohesive and accessible format poses a challenge, however. One way to do so entails choosing a specific learning activity. For example, NG[21] engineers nationwide donate their time and expertise to elementary school and high school classrooms. Volunteers split students into small groups and present them with an unorthodox method for solving a problem. The goal of these activities is for students to have fun while learning how exciting, creative, and extensive technology can be.

IBM's On Demand Community[22] offers resources for employees who wish to volunteer. These resources range from tutorials on useful participation in classrooms that have students with disabilities to a clearinghouse for volunteer opportunities. Employees who volunteer are motivated to participate by the chance to earn cash grants or computers for the schools or nonprofits with which they work.

Dimension	High	Medium	Low	Notes
Cost			✓	Mainly the cost of employee labor to update or adjudicate submissions to the site. Can be more costly if an online community is implemented.
Impact			✓	Indirect resources may never be used
Commitment		✓		To keep users coming, the resource should be refreshed regularly.
Sustainability		✓		Easy to sustain if users or employees are making updates to the site.

[18] Retrieved March 5, 2007 from http://www.curriki.org/xwiki/bin/view/Main/WebHome/
[19]Retrieved March 5, 2007 from http://developers.sun.com/learning/academic/
[20]Retrieved March 5, 2007 from http://educationcommons.org/commons/
[21]Retrieved March 5, 2007 from http://careers.northropgrumman.com/ExternalHorizonsWeb/company_overview/overview_outreach.jsp
[22]Retrieved March 5, 2007 from https://www-1.ibm.com/ibm/ondemandcommunity/

Academies. Unlike short-term summer camps or workshops, a company can make a long-term investment in a curriculum and infrastructure that can be established in a secondary school or junior college to teach specific technical skills and confer certification. For example, NG partners with a local high school to host an Aerospace Academy program in the Fairfax County, Virginia public school system. The program provides hands-on training, coupled with advanced computer technology and equipment.

Academies can provide specialized vocational training. Perhaps the most prominent example is the Cisco Networking Academy Program, a public/private partnership between Cisco, governments, education institutions, NGOs, and industry that was created to teach students how to design, build, and maintain computer networks. The Networking Academy is a comprehensive e-learning program that provides students with technology skills in partnership with an educational organization such as upper secondary school, college, or university, or even community-based organizations and nonprofits. Launched in 1997, Networking Academies now number more than 9,000 in 141 countries with an enrollment of approximately 95,000 students.

Dimension	High	Medium	Low	Notes
Cost	✓			A company can work with a local school to create an academy (which can be as small as one class). Or, it can create a package that can be "franchised" to any number of educational organizations. An initial start-up cost is entailed to establish relationships and develop curricula.
Impact	✓			Direct, because these programs provide in-depth exposure to career skills and can produce workers ready to enter the workforce. The sponsoring company may also have a chance to recruit from the graduates.
Commitment	✓			To realize the payoff of the initial investment, a company should plan to continue the program for some time.
Sustainability	✓			The content needs to be kept up to date.

Academies entail high risk because the initial investment may not pay off, and because the agency delivering the academy may not provide sufficient support.

Fellowships/Internships. These programs at the post-secondary level can offer good value for an investment. Fellowships confer special status on the awardees, and internships allow companies to try out potential employees and provide students with first-hand knowledge of job requirements. Fellowships at the graduate level are attractive for companies because graduate students tend to be more invested in specific career paths, as opposed to undergraduates who may be more interested in exploring options. By providing fellowships, which are usually coupled with internships, companies establish relationships and "test the waters" with potential hires.

A special kind of project-based internship is exemplified by the EPICS programs, started at Purdue University. These programs form interdisciplinary project teams to solve real-world problems for clients and can be combined with a scholarship or fellowship program. They involve more employee effort and industry-university collaboration than the other programs described above, but accompanying the high commitment and risk is high impact. Students who have a positive experience with a project may be encouraged to work in a STEM field, and working with a company's employee on a project can lead them to take a job at that company. Programs of this type also develop other skills such as teamwork and communication.

Dimension	High	Medium	Low	Notes
Cost	✓			Internships require hiring a student as an employee.
Impact	✓			Direct, companies can "try out" interns as prospective employees.
Commitment		✓		A company is committed to the internship or project for its duration.
Sustainability	✓			Easy to sustain, although project-based programs such as EPICS require investment to develop new projects for each team.

For a project-based internship to be successful, the company and the university should establish a long-term relationship. Moreover, employees who volunteer to help the project team will be working with a real client, which raises the stakes for the company. Therefore, the risk is also high because project teams may not follow through or may not be able to successfully deliver the desired product.

Other Types of Initiatives

After-School Programs. These programs are also long-standing investments that provide good visibility for a company, and like academies, workshops, and summer camps, typically target specific content areas, skills, and career exploration. After-school programs require the presence of agencies (a public or private school or nonprofits) to host the program and careful selection of good youth workers. Development costs can be the same or less as those for workshops, summer camps, etc., depending on the curriculum offered. The programs need time to grow and gather a base of attendees. Because attendance is optional, a program must be sufficiently attractive to draw students or must market itself to parents. Program impact can be significant, but may be hard to measure. One example is the Intel Computer Clubhouse Network.

K-12 Teacher Professional Development (TPD). IT workforce preparation requires students to start early in the academic pipeline, but if their teachers are unprepared, they are at a disadvantage. TPD programs allow companies to fund programs delivered by universities and colleges. If a company and a local college collaborate, the development cost for the course could be moderate. Alternatively, such courses may already exist, and companies may simply cover the tuition and substitute-teacher time for a teacher to attend the course. Risk is low because any investment in teachers can be seen as useful from a public-relations perspective. However, the sponsoring company remains at arms length from the outreach effort. Impact can be low—simply taking the training may not be enough to enable a teacher to offer a new class. An example is Advanced Placement Computer Science Institute of the University of California at Los Angeles/Los Angeles Unified School District.

Scholarships. Qualcomm's "Q" Awards for Excellence are part of a scholarship program for minority engineering students at the graduate level. The program focuses on academic achievement, leadership skills, and interest in wireless communications and the engineering field. "Q" Awards amount to $5,000 each. Companies can also specify eligibility requirements and selection criteria in addition to designating the scholarship amount.

Project-based Activities for Schools Run by Companies. IBM recently completed a large program called Reinventing Education that provided grants to schools, states, or the ministries of education of countries where IBM has a presence. Grants gave paid time to IBM employees to develop solutions to problems in education, in some cases using IBM technology, and in other cases developing new technology.

Re-tooling Retired Employees to Teach STEM Subjects. IBM employees can receive support to train for teaching while still employed at IBM. The "Class of 2006" has 100 (near-retirement) employees and retirees who are taking advantage of the program.

Because making a lasting impact may require multitrack efforts, companies with more resources may wish to pursue efforts in several of the areas discussed above. For example, IBM has invested in teacher training, career information, classroom/school technology, and employee volunteerism.

Conclusions

The IT profession is a dynamic and exciting field. Many of today's leaders such as Steve Jobs and Steve Wozniak were drawn to computing out of a personal passion for tool making or problem solving. We believe it is the responsibility of all of us in the field to share our passion with the next generation to allow them to make career decisions that are informed by their encounters not only with technology products, but also with technology professionals. We hope this white paper offers concrete guidance to companies seeking ways to reach out to their communities.

It is also important to bear in mind that IT workforce issues are not just the concern of an individual company, but that a healthy flow of talent is important to the IT industry as a whole and to our nation's ability to compete on a global scale. By pooling resources and partnering with school and universities, we can have the greatest impact. To learn more about partnering opportunities, we encourage companies to consider joining ACM SIGCSE[23] and attending its annual meeting. Companies may also wish to investigate a new National Science Foundation (NSF) initiative, C-PATH,[24] which offers funding to university-industry partnerships aimed at reinvigorating CS education.

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[23] Association for Computing Machinery's Special Interest Group for Computer Science Education, http://sigcse.org.

[24] *CISE pathways (C-PATH) to revitalized undergraduate computing education*. Retrieved March 7, 2007 from http://www.nsf.gov/pubs/2006/nsf06608.

Appendix: Reviews of IT Workforce Reports

National Academies, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* 2006

Findings:

This study commissioned by the U.S. Congress expressed deep concern that the United States is falling behind other nations in the sciences and engineering. It cited the statistic that in China 50% of all undergraduates receive their degrees in natural science or engineering, whereas in the United States the corresponding figure is 15% (p. ES-10). It also cited the estimate that in 2004, China graduated about 350,000 engineers, computer scientists, and information technologists with 4-year degrees, whereas the United States graduated about 140,000 (p. ES-10). It concluded, "[T]he committee is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength" (p. ES-2). The majority of the 543-page report focused on delineating 20 recommendations for action, including the following.

Recommendations:

1. Improve K-12 science education by recruiting 10,000 teachers annually with 4-year scholarships, enhance professional development for 250,000 teachers, and increase the number of students in AP and International Baccalaureate (IB) courses.
2. Enhance basic research by increasing federal investment by 10% per year over the next 7 years, providing 200 grants per year of $500,000 to early-career researchers, and initiate other federal projects.
3. Make the United States an attractive place to study by providing 25,000 undergraduate and 5,000 graduate scholarships annually to U.S. citizens, providing tax incentives for continuing education, and enacting visa and immigration reforms to attract foreign talent.
4. Create incentives for innovation by strengthening intellectual property laws, provide tax incentives to encourage private investment in research, and ensure ubiquitous broadband Internet access.

Microsoft, *The Future of Information Technology*, July 2006

Findings:

In this research report, Microsoft pointed to a decline in CS college enrollment as evidence that students perceive the field as a less attractive major than they did in the 1990s. It cited studies finding decreases in enrollment of between 30% and 39% in the last few years and suggested that the major factors were negative news coverage, fear of job loss due to outsourcing, and negative (but inaccurate) perceptions of the programming life. It also noted that participation by women and minorities in the CS major has declined relative to other majors (e.g., female enrollment in other science and engineering fields has *increased*.) These declines are of special concern, given that countries such as South Korea are graduating large numbers of engineers. Microsoft argued that these trends have negative implications not just for the computer industry, but also for American competitiveness in virtually all scientific and technological fields, given that so much of the infrastructure of scientific research depends on computing.

Recommendations:

Microsoft recommended that awareness of the CS enrollment crisis should be raised by conducting a concerted public information campaign focusing on seven audiences: industry, the public, government leaders, students, teachers, women and minorities, and immigration policymakers. The point of the campaign would be to inform these audiences about the attractiveness of the profession and its importance to national prosperity. Another major goal of the campaign would be to persuade policymakers to increase funding for government programs that will reform science education and recruit minority populations. Central to this reform would be updating the CS curriculum by introducing topics of clear relevance to social problems and students' everyday lives, and using a problem-based model of learning. The report also argued that it is important to reform immigration policies to enable foreign students to study in the United States.

The U.S. Chamber of Commerce*, Tapping America's Potential: The Education for Innovation Initiative,* 2005

Findings:

The Chamber of Commerce report conveyed a sense of concern similar to that of the Microsoft report, although it focused on the sciences and engineering professions more broadly, because it viewed the United States as being at risk of falling behind in other scientific fields in addition to CS. It pointed to the following statistics as cause for alarm:

- By 2010, if current trends continue, more than 90% of all scientists and engineers in the world will be living in Asia.
- South Korea, with one-sixth of our population, graduates as many engineers as the United States.
- Although U.S. fourth graders score well in mathematics and science in comparison with foreign counterparts, by 12th grade they fall near the bottom or dead last.
- The number of engineering degrees awarded in the United States has fallen 20% from the peak year of 1985.

The Chamber of Commerce had a somewhat different perspective from Microsoft's regarding foreign nationals, regarding them as (a) a diminishing source of talent because of U.S. security concerns and increasingly attractive opportunities in their home countries, and (b) an increasing source of competition should students from abroad return to their home countries with prestigious American degrees. It noted that more than 50% of all engineering doctoral degrees awarded by U.S. engineering colleges are to foreign nationals. It therefore put special focus on the importance not only of attracting foreign talent, but retaining it.

Recommendations:

The core recommendation of the report is that the country double the number of science, technology, mathematics, and engineering B.A.'s by 2015 by:

1. Building public support for making science education a national priority through communication with the public, and expanding the State Scholars Initiative.
2. Motivating students (particularly from under-represented groups) to enter IT careers with scholarships, loan-forgiveness programs; expanding existing NSF, Department of

Defense, and NASA outreach programs; eliminating security clearance backlogs; and reforming college curricula.
3. Upgrading K-12 education by attracting more and better teachers; supporting teacher recruitment, professional development, and online curricular resources; providing incentives to colleges to produce more science majors; and offering online curricular resources.
4. Reforming immigration policies by expediting visa applications and granting a larger number of permanent visas.
5. Boosting funding for basic research in the physical sciences by reversing budget declines for NSF and other science-based agencies, increasing budgets by 7% annually to offset inflation.

Duke University, *Framing the Engineering Outsourcing Debate: Placing the United States on a Level Playing Field with India and China*, 2005

Findings:

This study, conducted by the Master of Engineering Management program at Duke University, questioned claims of a domestic shortage of engineering talent. It examined what the word "engineer" means in China and India, and found that that term can include the equivalent of motor mechanics and industrial technicians, as well as graduates of four- year baccalaureate programs. It drew a distinction between "dynamic" engineers and "transactional" engineers, and suggested that the American meaning of the word "engineer" is limited to the former; a dynamic engineer is capable of high-level problem-solving using scientific knowledge, whereas a transactional engineer is typically trained to carry out only rote and repetitive tasks. The study found that once this linguistic confusion had been eliminated, the United States still produces more highly qualified engineers *per capita* than any other country. It quoted a McKinsey study finding that only 10% of Chinese engineers and 25% of Indian engineers could actually work for a multinational company (e.g., compete with American engineers) and cited language barriers and cultural differences as among the reasons why.[25] The report concluded, "It is clear that the U.S. is not in the desperate state that is routinely portrayed. The country needs to maintain its focus on improving the quality of education and maintain its momentum, but there is no imminent crisis."

Dr. Norman Matloff, *Debunking the Myth of a Desperate Software Labor Shortage,* 2002

Findings:

Matloff, a professor of computer science at the University of California at Davis, argues that industry claims of a labor shortage are specious. He points to the industry's average hiring rate of 2% of its applicants, and the fact that salaries in the field have risen at a relatively low 7 or 8% per year; between1995-1999, wage growth for CS graduates was less than for graduates in business administration. "When the industry claims a shortage of programmers," Matloff writes, "what they mean is a shortage of cheap programmers." Young programmers and overseas programmers are preferred because they can be hired at low salaries and made to work long hours. Older programmers, on the other hand, find it extremely difficult to find work even when they have stellar resumes. Matloff singles out the H1-B visa program for particular criticism. His compiled statistics suggest that H1-B employees are significantly underpaid compared with their

[25] Farrell, D., Laboissière, M., Rosenfeld, U., Stürze, S., & Umezawa, F. (2005). *The emerging global labor market: Part II—The supply of offshore talent in services*. McKinsey Global Institute.

American counterparts. Furthermore, because their visas depend on specific employers, the jobs amount to “indentured servitude” because employees cannot seek better paying or more rewarding work.

Recommendations:

Matloff argues that if American businesses focused on competence rather than knowledge of specific programming languages, and if they retrained older employees instead of hiring cheap ones fresh out of school and from overseas, the labor shortage would vanish.