University-Industry Partnerships with High Potential for Impact

Maria Klawe and Telle Whitney

Recent significant changes in the high-tech industry sector are raising the level of collaboration between private companies and universities, bringing about a cultural shift in higher education. This deep—but not immediately obvious—shift affects research, pedagogy, funding, and other important areas of the academy. One active area of collaboration between these two institutions is in increasing the participation and impact of women in technology, especially in areas such as computer science and engineering, where women are significantly under-represented. In this chapter, we discuss the ramifications of the changing relationship between industry and higher education and explore the resultant opportunities and potential threats facing campus leaders today. We also describe some recent university-industry initiatives focused on women and technology.
Industry Changes

Over the past 20 years, the major U.S. private research laboratories in the information technology and communications sector—AT&T, Bell, IBM, and Xerox—have downsized considerably and substantially reduced their efforts in independent, fundamental research. Today their focus is almost entirely product related. The only exception to the downsizing trend is Microsoft’s laboratory, which has been growing steadily and now has approximately 700 researchers, a small fraction of whom are doing independent research in the same sense as they would if they were at a university. Meanwhile, start-up companies are dramatically increasing their research activities and, although ultimately product focused, often produce important research results.

Another change in the high-tech sector, especially among large companies like Hewlett-Packard, Intel, and Microsoft, is the rising concern about the low number of women in technical positions, especially at the most senior levels. IBM has been concerned with this issue for the past 25 years and has the best record of women’s participation in technical career paths. IBM counts at least six talented women in its top technical position, that of fellow. Yet despite IBM’s many initiatives and programs, participation by women remains far lower than the company would like to achieve.

What effect do these two changes have on higher education?
Research

The decline in large industry laboratories has led to the virtual disappearance of the interdisciplinary, pure, and applied research communities that once thrived in the industry lab and are sometimes difficult to nurture in an academic environment. The labs served as fertile mixing pots where researchers working in different disciplines frequently participated in stimulating discussions and arguments. As almost anyone who works in science or engineering will agree, the most exciting problems lie at the interface between disciplines—not just between science and engineering, but at the interface of those disciplines with the humanities and social sciences. With the demise of the large research labs, we've lost the open, interdisciplinary mix and its vast potential for discovery. Universities can help fill the void by supporting such environments and ultimately will benefit from the work resulting from these collaborations.

Meanwhile, research in the industry labs has become focused on products, often guided by executives who understand the company's market but are far removed from research opportunities. The projects may be fascinating and exciting, but they are conducted in a tightly integrated fashion, led by managers who point the direction the research is going—in contrast to the independent research done by individual faculty members who often are driven simply by a passion to discover more about a particular area. This industry research often
leads to short-term product innovation, but disallows more far-reaching results that previously enabled industry's longer-term product strategies.

As their own capacity has declined over the past two decades, companies are funding more basic and applied research at universities. At the same time, start-ups are ratcheting up their research activities, so venture capital has become another new source of funding for academic research. Both are rife with potential conflict-of-interest situations, however. For example, many questions about intellectual property rights arise as faculty and students are encouraged or tempted to cross the line from academia to starting their own companies. Universities need to address these situations and help train faculty and graduate students to effectively handle the complex ethical issues arising with greater frequency throughout the academy.

Finally, the downsizing of industry labs has also generated a steady flow of researchers from those labs into universities and, to a lesser extent, to smaller liberal arts colleges. The notion of moving from an industry lab to a liberal arts college is not as unconventional as it might first appear. To succeed in the industry labs, researchers had to learn how to effectively communicate about their work; moreover, the industry labs traditionally encouraged their scientists to teach courses and provided strong management training programs. It seems that many former lab researchers have proven to be excellent teachers and have considerably more management expertise than their peers who have spent their careers in academe.
The shift in industry research focus means that the job prospects for Ph.D.s going into industry are quite different than in the past, as they can expect to be working on applied and product-related areas rather than on basic research. This change also means a shift in the skills needed by our students, virtually all of whom will end up on team-based projects. Yet Ph.D. programs for scientists and engineers continue to offer little formal training about how to work effectively in teams. To succeed, our students will need to better understand how to apply their knowledge, as well as product-oriented research methods.

As start-ups undertake more research, it is also more likely that new Ph.D.s will work for small companies. The dynamics of working in a small company with three or five or twenty-five people are very different from working in a company with several hundred or several thousand employees. And yet nothing in terms of the education offered our students seems to take that into account. In a small company, for example, an employee is likely to go through frequent job transitions without the benefit of a human resources department. It would be to our students’ benefit to prepare them to face issues related to interactions with fellow employees, teach them how to set goals, and explain how they might be evaluated.

As a means to improve its workforce, industry is interested in academic programs that combine science, technology, and business, as well as graduates who have been trained to be
more aware of the opportunities that lie at the intersection of
disciplines. Further, industries generally are extremely pleased
with graduates of academic programs that give students the
opportunity to alternate academic and work terms, in that
such programs help students develop team and leadership
skills and benefit from real-life experiences that simply cannot
be gained in the classroom or lab. Selective colleges and uni-
versities would do well to rethink their historical bias against
such programs.

To reiterate, training in ethics is crucial to helping students
and faculty navigate the complex ethical situations in which
they are increasingly likely to find themselves. The intellectual
property issue has proved particularly troublesome, despite
years of hard work on the part of institutions to raise the fac-
ulty's level of awareness of the issues. For example, if a faculty
member owns a company and has graduate students working
for it, who owns the creative intellectual property that stems
from those efforts? Is it inappropriate if the research a faculty
member is doing on a federal research grant also contributes to
his or her private venture?

Funding

Twenty years ago, it was not unusual for industry to support
universities by funding a building or endowing a chair—all as
part of enhancing the common good. Today, nearly all corpo-
rate giving is tied directly to corporate goals, and it seems that undirected gifts have virtually disappeared.

Corporate goals may be related to specific research a company has outsourced to a university or perhaps to influencing the educational process in ways such as those outlined above related to shaping the workforce. Or a company may simply want to place its products so that graduates will expect to use them in the workplace after graduation. At a time when research funding has become increasingly difficult to secure, professors, and especially young professors launching their career, need to be careful that industry-sponsored research does not become overly focused on the short term and to ensure that as academics they stay true to furthering their field.

Diversifying the Technology Workforce

Industry’s interest in higher education runs deeper than the research it funds on campus. The corporate sector, for example, has been far more proactive than academia in its efforts to build a workforce more representative of the general population. In particular, technology companies are frustrated that U.S. colleges and universities are not producing enough female and minority graduates to hire. Because industry has decided that diversifying the workforce is important to their overall business strategy, this issue undoubtedly will influence ongoing corporate relations with universities. In fact, industry
and higher education will need to collaborate to achieve the cultural shifts necessary to build a diversified workforce.

Corporate executives realize that being limited to a narrow segment of the population for hiring scientists and engineers is affecting their design efforts, project teams, customer interactions, and so forth. They have also come to realize that it is not enough to address this issue on a local scale; as a result, companies are reaching out to higher education to work together to encourage women and minorities to study engineering and computer science. They realize that to solve their problem, they need to start much earlier than entry into their company.

The situation in computer science is particularly disturbing because it is the only area in science and engineering in North America in which participation by women has fallen over the past 25 years. Women now comprise fewer than 20 percent of the undergraduate computer science majors in North American Ph.D.-granting computer science departments, down from the approximately 35 percent in the late 1970s. In other areas of science and engineering, women’s participation increased significantly over the same period. In fields such as biology and chemistry, women comprise more than 50 percent of the undergraduate majors, and in mathematics, chemical engineering, and civil engineering they comprise more than 40 percent. However, in physics and most other areas of engineering the percentage of undergraduate majors who are women has been hovering at about 20 percent for the past decade. Efforts to understand and address the low participation of women in sci-
ence and engineering must consider all stages in the pipeline: K–12, undergraduate, graduate, and both academic and industry workforces.

How Children Perceive Engineering and Computer Science

Research studies have shown substantial differences between girls’ and boys’ interests in careers and courses related to engineering and computer science by age 13 or 14. For example, a 1998–99 study of 7,300 Vancouver students in grades 8, 10, and 12, conducted at the University of British Columbia and funded jointly by IBM Canada and the Natural Science and Engineering Research Council of Canada, showed that girls perceived engineering, computer science, and physics as less interesting than boys did and expected to do less well in related courses. The areas that appealed to girls more than boys were English, fine arts, and psychology. The areas found to appeal equally to both sexes were geography and history, and the areas in which slight differences were found were mathematics, chemistry, and business (more appealing to boys) and biology (more appealing to girls). The gender differences were present and almost identical at the three grade levels. Moreover, at each grade both girls and boys indicated that they expected personal interest and ability to be the most important factors in choosing their careers. Given the lower interest and expec-
tations of performance, perhaps it is not surprising that fewer young women choose to major in engineering, computer science, and physics in college.

Most elementary and middle schools have no courses that cover material in any significant way related to computer science or engineering. What, then, causes girls and boys to have such different levels of interest in computer science and engineering before entering high school? One factor is the difference in children's interactions with computers. Boys spend more time playing computer games and exploring the intricacies of computers. More boys attend computer camps, learn to program as preteens (usually because they want to be able to create their own computer games), and take pride in being viewed as computer experts. Most girls use a computer as frequently, but spend their computer time doing homework assignments, reading e-mail or instant messages, and surfing the Web. For most girls, computers are useful tools rather than objects of intrinsic interest.

Another important factor is the prevailing image among the general population of computer scientists and engineers. Both occupations are perceived as solitary, for people with little or no interest in social interactions. Computing careers are equated with programming 24×7, or working alone in front of a computer screen, which is particularly unappealing to most girls and women. While there are certainly many computing careers that require a substantial amount of programming (usually in a maze of cubicles rather than in complete isolation), virtually all computing careers today also require team-
work, excellent people and communication skills, use of expert knowledge in areas outside of computer science, and creativity. In reality, a career in computing or engineering is just as interesting as careers in medicine or law and has as much or more potential for helping people and solving societal problems.

Changing the image of engineering and computing will require campaigns as ambitious as the no-smoking campaign waged in the United States, which has been enormously successful in changing our cultural view of smoking. A group from several organizations including nonprofits (the Association for Computing Machinery, the Anita Borg Institute for Women and Technology), universities (Princeton, University of Colorado, University of California, Berkeley, and Mills College) and companies (Hewlett-Packard, Intel, Microsoft, Google) are currently working to initiate a marketing campaign to change the image of the computer professional.

The Anita Borg Institute for Women and Technology

The Anita Borg Institute for Women and Technology is a nationally recognized nonprofit organization whose programs have a track record of changing both the presence of women in academia and industry and the perception of technology to be a more inclusive discipline. Founded in 1997 by Dr. Anita Borg, the institute brings together an unusual mix of academics and industry and includes in its communities many of today's technology thought leaders. Its mission is to increase the
impact of women on all aspects of technology and the positive impact of technology on the lives of the world’s women.

The image campaign described above is one of the industry-university collaborations organized by the Anita Borg Institute. The institute’s programs, including Systers, the Grace Hopper Celebration of Women in Computing, the Virtual Development Center, its new leadership initiative, and a significant collaborative effort under the name of the National Center for Women and IT, all involve participation from both industry and academia. The two communities learn from each other and appreciate each other’s presence.

Although the institute was founded in 1997, its programs date back to 1987, when Dr. Borg founded Systers. The Systers Online Community for women in computing is the first and largest such online community, engaging and supporting nearly 3,000 women in 38 countries. Systers has been in active use since its start and is a place for women to find answers to the issues they deal with in their lives both as women and as technologists. For many women working in computer science, who often feel very alone and isolated, Systers is their first opportunity to reach out to other women with similar experiences.

Founded in 1994, the Grace Hopper Celebration of Women in Computing Conference is the largest gathering of technical women in the world. The conference is designed to bring the research and career interests of women in computing together. Presenters are leaders in their respective fields, representing industrial, academic, and government communities. Leading
researchers present their current work, and special sessions focus on the role of women in today's technology fields. Past Grace Hopper conferences have resulted in collaborative proposals, networking and mentoring for junior women, and increased visibility for the contributions of women in computing. Universities' graduate computer science programs increasingly send many and sometimes all of their female students to the Grace Hopper conference. For these students, often struggling in a male-dominated environment, the chance to see world-class women technologists describe their work and to be in an environment with more than 500 women computer scientists can change their lives and cement their resolve to continue in their chosen study.

The Virtual Development Center (VDC) is an undergraduate education program whose purpose is (1) to offer a team-based approach to technology creation and (2) to make a direct connection between this creation and its social impact. The latter goal is based on the observation that female students benefit from classes where they see the social application of their engineering work. The VDC is a network of nine colleges and universities, each of which takes the important concepts of socially relevant design and creates a course where students work directly with local community groups. The courses use communication styles that emphasize listening—students are often humbled by the sharp difference between their perception of community needs and the actual needs. Classes are typically half women, an unusual occurrence in engineering schools. One perhaps surprising result is that the gender bal-
The internet and the university

ance of these classes occurs naturally, as the women engineering students are drawn to classes that they perceive have direct impact. The VDC teams often include students from not only computer science and engineering, but also political science, economics, business, and communications; the VDC products bridge many disciplines. For many students, particularly women, it is their first exposure to how technology’s impact on society is realized.

A new collaborative endeavor, the National Center for Women and IT (NCWIT), is an effort aimed at changing, in a systematic way, the participation of women in IT at each level of the pipeline. By bringing together a diverse set of organizations as hubs, each with a unique strength; by developing a research agenda in areas that are currently under-served; and by actively disseminating best practices through its communities, NCWIT intends to be a driving force in achieving equal participation of women and men in academic and industrial careers within 20 years. The founding organizations of this effort are the Alliance for Technology, Learning, and Society (ATLAS) Institute at the University of Colorado at Boulder and the Anita Borg Institute. The current hubs include the Anita Borg Institute, the Association of Computing Machinery (ACM), the University of California (both Berkeley and Irvine), the University of Colorado, the Computing Research Association (CRA), Georgia Tech, and the Girl Scouts of the USA. Although the work of NCWIT is new, response and interest from both academia and industry has been strong. The results of this effort over the next few years should be significant.
Opportunities and Threats

Collaboration between industry and higher education presents a number of opportunities and possible threats. The additional funding from industry is a huge opportunity to conduct academic research, allowing universities to pursue knowledge and make positive contributions to society. Technology transfer from discoveries on campus can improve peoples’ lives and generate additional funding to support other worthwhile activities universities wish to pursue. And because industry needs and wants to collaborate on a number of levels, higher education has the opportunity across the academic spectrum to make a positive impact.

The potential threats posed by industrial funding of academic research include the loss of independence in the form of outside influence over the direction of the work and the diminishment of pure, fundamental research. We recognize the seriousness of these possibilities, but firmly believe that higher education can control the outcome—it is up to higher education’s leaders to create a good and acceptable balance between these pressures. Indeed, industry does not want us to sell out; industry values the fact that higher education has for several hundred years demonstrated the ability to focus on research and education and thus presents a long-term continuum of stability—in sharp contrast to the short-term pressures that dominate the corporate realm.

The demise of the interdisciplinary industry labs described above presents an exciting opportunity for higher education.
Because they recognize the value of such environments, federal government funding agencies such as the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA) are working hard to create interdisciplinary research centers—not just at single universities, but also often at groups of universities—where pure and applied researchers in different disciplines can work and interact. Researchers flowing from the industry labs into academia add to and enrich this mix, as does collaboration with industry. One problem this creates for faculty is that the value of interdisciplinary and team-led research for purposes of promotion and tenure still lags behind that placed on individual scholarship, partly because of the difficulty of evaluating such work. Good evaluation mechanisms must be created and put in place so that interdisciplinary and team research is truly supported.

Faculty involvement with industry and their own start-ups also presents both opportunities and problems. The advantage lies in the enrichment of undergraduate and graduate education with the real-world experiences of faculty, helping students better understand the applicability of their knowledge and almost certainly improving the mentoring and career advice such faculty can offer. The disadvantage is in losing faculty to their business ventures, either above board or surreptitiously, for significant amounts of time. Finally, the conflicts of interest and intellectual property issues that arise in these situations can be extremely complicated and difficult to address.
Conclusion

In a very real sense, increased collaboration between industry and higher education has brought the creative engine of the knowledge economy to rest on the shoulders of academic researchers. The rise in “real world” research and education in colleges and universities has generated exciting opportunities with the potential to shift higher education’s culture—for example, by embracing the opportunity for faculty to move back and forth between industry and academia. Similarly, industry’s demand for more women and minority graduates in computer science and engineering is pushing universities to understand and address the current low rates of participation. The shift, however, is not without risk to fundamental principles such as the freedom of inquiry that underlies higher education. Whether the right balance in this burgeoning partnership ultimately is struck will depend largely upon how higher education’s leadership responds to the challenges at hand.

Maria Klawe is Dean of Engineering and Applied Science at Princeton University. Telle Whitney is President of the Anita Borg Institute for Women and Technology.