Recent significant changes in industry are raising the level of collaboration between the private commercial sector 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. Maria Klawe, dean of engineering at Princeton University, spent eight years as a researcher in an industry laboratory and has been involved with a number of technology start-ups. She discusses the ramifications of the changing relationship between industry and higher education, and explores the resultant opportunities and potential threats facing campus leaders today.

Industry Changes

Over the past 20 years, the United States’s major private research laboratories—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, smaller start-up companies are dramatically increasing their research activities. What effect do these 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 there. The labs had served as fertile mixing pots where researchers in different disciplines frequently talked to each other. As most 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 as well. With the demise of the large research labs, we have lost the open, interdisciplinary mix and its vast potential for discovery. Universities can help fill the void by nurturing and supporting such environments.

Meanwhile, research in the industry labs has become focused on products. 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.

As their own capacity has declined over the last two decades, companies are funding more of both basic and applied research at universities. At the same time, start-ups are ratcheting up their research activities, and so venture capital has become another new source of funding for academic research. Both are rife with potential conflict of interest situations, however. 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 be successful in the industry labs, researchers have 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.

Education

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 be successful, 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 25 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 how to interactions with fellow employees, how to set goals, and how they might be evaluated.

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

And, 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 faculty'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?

Social Change

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 public. Indeed, industry is frustrated that U.S. colleges and universities are not producing enough female and minority graduates to hire. Because industry has decided that diversifying its workforce is important, this issue undoubtedly will influence ongoing corporate interactions with universities.

Corporate executives realize that being limited to a narrow segment of the population for hiring scientists and engineers is affecting their design efforts, teams, customer interactions, and so forth. They also realize that it is not enough to address this issue on a local scale; as a result, companies are beginning to reach out to higher education to work together to encourage women and minorities to study math and science. One of the first steps is to change the negative image of mathematicians and computer scientists—one that greatly discourages girls' interest from an early age. The campaign being undertaken to influence this cultural shift is as ambitious as the no-smoking campaign waged in the United States, which has been enormously successful in changing our cultural view of smoking. The collaborative efforts of industry and higher education will be needed to achieve the cultural shifts envisioned to, in the end, achieve a diversified workforce.

Opportunities and Threats

Collaboration between industry and higher education presents a number of both opportunities and potential threats. First, 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 people's 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. I 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 Defense Advanced Research Projects Agency (DARPA) are working hard to create interdisciplinary research centers—not just at single universities, but 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 the value 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 with 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. The shift, however, is not without risks to fundamental principles such as the freedom of inquiry that undergirds higher education. Whether the right balance in this burgeoning partnership ultimately is struck will largely depend upon how higher education’s leadership responds to the challenges at hand.

Maria Klawe is dean of engineering and professor of computer science at Princeton University. She formerly held the position of dean of science and professor of computer science at the University of British Columbia. Klawe is president of the Association of Computing Machinery, the North American professional society for computer scientists and computer professionals.