The IT Forum:
Preparing for the Revolution Redux

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We live in a time of great change, an increasingly global society, knitted together by pervasive communications and transportation technologies and driven by the exponential growth of new knowledge. It is a time of challenge and contradiction, as an ever-increasing human population threatens global sustainability; a global, knowledge-driven economy places a new premium on workforce skills through phenomena such as off-shoring; governments place increasing confidence in market forces to reflect public priorities even as new paradigms such as open-source technologies challenge conventional free-market philosophies; shifting geopolitical tensions driven by the great disparity in wealth and power about the globe, national security, and terrorism.[1] Yet it is also a time of unusual opportunity and reason for optimism as these same technologies enable the formation of new communities and social institutions, better able to address the needs of our society.

Rapidly evolving information technology has played a particularly important role both in expanding our capacity to generate, distribute, and apply knowledge. This technology is evolving very rapidly, linking people, knowledge, and tools in new and profound ways. It is driving rapid, unpredictable, and frequently disruptive change in existing social institutions. But since information technology can be used to enhance learning, creativity and innovation, intellectual span, and collaboration, it also presents extraordinary opportunities as well as challenges to an increasingly knowledge-driven society.

The implications for discovery-based learning institutions such as the research university are particularly profound. The relationship between societal change and the institutional and pedagogical footing of research universities is clear. The knowledge economy is demanding new types of learners and creators. Globalization requires thoughtful, interdependent and globally identified citizens. New technologies are changing modes of learning, collaboration and expression. And widespread social and political unrest compels educational institutions to think more concertedly about their role in promoting individual and civic development. Institutional and pedagogical innovations are needed to confront these dynamics and insure that the canonical activities of universities – research, teaching and engagement – remain rich, relevant and accessible.

The Impact of Information Technology on the Future of the Research University

It was just such concerns that stimulated the National Academies to launch a major project to understand better how this technology was likely to affect the research

university. The premise of the study was a simple one: The rapid evolution of digital technology will present many challenges and opportunities to higher education in general and the research university in particular. Yet there was a sense that many of the most significant issues are neither well recognized nor understood either by leaders of our universities or those who support and depend upon their activities. The first phase of the study was aimed at identifying those technologies likely to evolve in the near term (a decade or less) that might have a major impact on the research university and examining the possible implications of these technology scenarios for the research university.

The steering group for the effort was comprised of leaders from higher education, the chief technology officers of major IT companies, and leaders in national science policy. This group met on numerous occasions over a two-year period to consider these issues, including site visits to major technology laboratories such as Bell Labs and IBM Research Labs and drawing upon the expertise of the National Academy complex. At the end of this period, over one hundred leaders from higher education, the IT industry, and the federal government, and several private foundations convened for a two-day workshop at the National Academy of Sciences to focus this discussion. Beyond the insight brought by these participants, perhaps even more striking was their agreement on a number of key issues.

The first finding was that the extraordinary pace of information-technology evolution is likely not only to continue for the next several decades, possibly even accelerating. Hence, in thinking about changes to the university, one must think about the technology that will be available in 10 or 20 years, technology that will be thousands of times more powerful as well as thousands of times cheaper. The second finding was that the impact of IT on the university is likely to be profound, rapid, and disruptive, affecting all of its activities (teaching, research, service), its organization (academic structure, faculty culture, financing, and management), and the broader higher education enterprise as it evolves toward a global knowledge and learning industry. If change is gradual, there will be time to adapt gracefully, but that is not the history of disruptive technologies. As Clayton Christensen explains in *The Innovators Dilemma*,[2] new technologies are at first inadequate to displace existing technology in existing applications, but they later explosively displace the application as they enable a new way of satisfying the underlying need.

While it may be difficult to imagine today's digital technology replacing human teachers, as the power of this technology continues to evolve 100- to 1000-fold each decade, the capacity to reproduce all aspects of human interactions at a distance with

arbitrarily high fidelity could well eliminate the classroom and perhaps even the campus as the location of learning. Access to the accumulated knowledge of our civilization through digital libraries and networks, not to mention massive repositories of scientific data from remote instruments such as astronomical observatories or high energy physics accelerators, is changing the nature of scholarship and collaboration in very fundamental ways.

The third finding stresses that although information technology will present many complex challenges and opportunities to universities, procrastination and inaction are the most dangerous courses to follow all during a time of rapid technological change. Attempting to cling to the status quo is a decision in itself, perhaps of momentous consequence.

The first phase of this study, its conclusions, and its recommendations were published in a report, *Preparing for the Revolution*, available both online and through hard copy from the National Academies Press.[3]

The IT-Forum

More recently, the National Academies have extended this effort to involve directly a large number of research universities by creating a National Academy roundtable on information technology and research universities ("the IT-Forum") to track the technology, identify the key issues, and raise awareness of the challenges and opportunities. The IT Forum has also conducted a series of workshops for university presidents and chief academic officers in an effort to help them understand better the transformational nature of these technologies and the importance of developing strategic visions for the future of their institutions.

The IT Forum began its activities in spring of 2003 with a day-long workshop involving two dozen presidents and chancellors of major research universities at the spring meeting of the Association of American Universities (AAU). To launch the discussion, Louis Gerstner, retired CEO of IBM, spoke at a dinner meeting the evening before the workshop to share with the presidents some of his own observations concerning leadership during a period of rapid change. The IBM experience demonstrated the dangers of resting on past successes. Instead, leaders need to view information technology as a powerful tool capable of driving a process of strategic change, but only with the full attention and engagement of executive leadership– meaning university presidents themselves.

Noting that university presidents listen most carefully to their own voices, the workshop was organized about several panels of the participating presidents. The first

panel was asked to discuss what was currently in their in-out box, the here-and-now issues. These included the usual concerns such as how to meet the seemingly insatiable demand for computing resources (particularly bandwidth), how to pay for this technology, and how to handle privacy and security issues. It is probably no surprise that that most of the presidents believed that they had these issues well in hand–a perception quite different than we were to find with their provosts several months later.

Members of the IT Forum then attempted to move the discussion farther into the future and elevate it to a more strategic level by posing a number of provocative possibilities to the presidents. For example, how would adapt their library planning to the very real possibility that within a decade, the entire Library of Congress (about 10 TB) could be contained in a consumer device about the size of a football (a size university presidents understand well)–or more to the point of students, an iPod? How would the rapid evolution of *cyberinfrastructure*–the hardware, software, organizations, people, and policy increasing undergirding scientific research–into functionally complete environments for scholarship and learning affect their faculty and students? What if their students utilized IT to take control of their learning environments? These rhetorical hand-grenades triggered a broader discussion of related concerns such as the technological generation gap among students and faculty, the disruptive force of the marketplace brought onto campus by IT, and the disaggregation and reaggregation of the traditional roles and functions of the university.

As the discussions moved on to consider increasingly unpredictable futures, there was a growing recognition of the challenge of providing leadership in the face of such uncertain futures. Finally one of the presidents suggested that he had no idea how presidents were to lead in such a chaotic environment, and that he and his colleagues needed help. Hence, the workshop had managed to bring the presidents through several critical stages: from denial to acceptance to bargaining to seeking help…[4]

The IT Forum followed several months later with a very similar workshop for the provosts of AAU research universities. Again the session began by first asking a panel of provosts to lay out the issues as they saw them at the moment, then to move the discussion to a longer-term perspective, and finally to conclude with a discussions of next steps. The near-term concerns of the provosts were very similar to those of the presidents: network and bandwidth manage, the financing of technology, the protection of security and privacy, and data management and preservation.

Perhaps not surprising was a far greater degree of sophistication among the provosts in understanding and addressing these issues than shown by the presidents, perhaps since as chief academic officers, they were on the front line. But here there was

an even more significant difference: unlike the presidents, the provosts recognized (or at least admitted) that these were very difficult issues and that they certainly did not have the answers. The provosts also were willing to discuss issues that would require major cultural changes in their institutions. For example, they expressed growing concern about the degree to which universities were being disadvantaged by the effective monopolies created by IT providers. As one provost put it, universities acted like deer paralyzed in the oncoming headlights, continuing to re-invent the wheel and getting devoured by the marketplace. The provosts were essentially unanimous in their belief that it was time for the universities to set aside their competitive instincts and to build consortia to develop together the technologies to support their instructional, research, and administrative needs through open-source paradigms that would break the stranglehold of the current IT marketplace.

Many provosts suspected that while the faculty believed they knew how their students learned, in reality they had not a clue, particularly in technology-rich environments. This was a theme we were to encounter again and again in our later workshops. The provosts believed that their universities needed far more sophisticated help to understand the learning and cognitive processes characterizing contemporary students, although they also recognized the disruptive nature of these studies which might eliminate over time the rationale for the lecture-classroom paradigm.

In-Depth Meetings

To explore in depth several of the issues raised in the workshops with presidents and provosts, the IT Forum arranged several more focused site visits:

IT-Forum Meeting on "Cognition, Communication, and Communities"
Carnegie-Mellon University (September 5-6, 2003)

To learn more about how learning occurs in technology-intensive environments, the IT Forum held its fall 2003 meeting at Carnegie Mellon University, renown both as one of the nation's most wired—and now wireless—campuses and also for its strength in the cognitive sciences. As the CMU faculty put it, their students have embraced IT to become a transformative force, frequently forcing the faculty to react to their learning activities. An example is the way students use this technology for communication. From instant messaging to e-mail to blogs to friendster, students are in continual communication with one another, forming learning communities that are always

interacting, even in classes (as any faculty member who has been "Googled" can attest). A young professor of physics told us he had been forced to give up trying to teach difficult concepts in his classes. Instead he introduces a topic by pointing to several resources until a few students in the class figure out a way to teach themselves the concept. Then they teach their fellow students, and through peer-to-peer learning, the concepts propagate rapid through the class.

Today's students are active learners, building their own knowledge structures and learning environments through interaction and collaboration. Their approach to learning is highly nonlinear rather than following the sequential structure of the typical university curriculum. They are adept at multitasking and context switching. And they are challenging the faculty to shift their instructional efforts from the development and presentation of content, which is more readily accessible through the web and open-content efforts such as the Open CourseWare initiative of MIT, and instead become more of a mentor and consultant to student learning.

Some CMU faculty members have concluded that perhaps the best approach in these technology-rich environments is to turn the students loose, letting them define their own learning environments. Peer-to-peer learning is rapidly replacing faculty teaching as the dominant educational process on this technology-rich campus. There is not yet a consensus among the faculty as to where they are headed, but there is strong agreement that the net generation is both challenging and changing the learning process in very fundamental ways.

IT Forum Meeting on "Virtual Worlds" at
The Institute for Creative Technologies, Marina del Rey (March 11, 2004)

To understand new paradigms of technology-assisted learning, the spring 2004 meeting of the IT-Forum was held at the Institute for Creative Technologies in Marina del Rey. Here, the University of Southern California is applying the entertainment and gaming technologies developed by Hollywood and others to create a "holodeck" to train military officers in high level cognitive activities such decision making and leadership. They have learned something that universities have yet to grasp: how technology can be used to create an emotional connection between knowledge and learning.

On a deeper level, information technology is forcing us to rethink the nature of literacy: From literacy in the oral tradition…to the written word…to the images of film and then television…to the computer and multimedia. Of course there are many other forms of literacy: art, poetry, mathematics, science itself, etc. But more significantly, the

real transformation is from literacy as "read only, listening, and viewing" to composition in first rhetoric, then writing, and now in multimedia.

Increasingly, we realize that learning occurs not simply through study and contemplation but through the active discovery and application of knowledge. From John Dewey to Jean Piaget to Seymour Papert, we have ample evidence that most students learn best through inquiry-based or "constructionist" learning. As the ancient Chinese proverb suggests "I hear and I forget; I see and I remember; I do and I understand." To which we might add, "I teach and I master!!!"

But here lies a great challenge. As noted earlier, creativity and innovation are key not only to problem solving but more generally to achieving economic prosperity and sustaining national security in a global, knowledge-driven economy. Yet while universities are experienced in teaching the skills of analysis, we have far less understanding of the intellectual activities associated with creativity. In fact, the current disciplinary culture of our campuses sometimes discriminates against those who are truly creative, those who do not fit well into our stereotypes of students and faculty.

The university may need to reorganize itself quite differently, stressing forms of pedagogy and extracurricular experiences to nurture and teach the art and skill of creativity and innovation. This would probably imply a shift away from highly specialized disciplines and degree programs to programs placing more emphasis on integrating knowledge. To this end, perhaps it is time to integrate the educational mission of the university with the research and service activities of the faculty by ripping instruction out of the classroom–or at least the lecture hall–and placing it instead in the discovery environment of the laboratory or studio or the experiential environment of professional practice.

IT-Forum Meeting on "Cyberinfrastructure" at
University of Michigan, Ann Arbor (November 11-12, 2004)

In fall of 2004, the IT Forum met at the University of Michigan to consider the important study by the National Science Foundation Blue Ribbon Advisory Panel on Cyberinfrastructure. The panel concluded that we are approaching an inflection point in the potential of rapidly evolving information and communications technology to transform how the scientific and engineering enterprise does knowledge work, the nature of the problems it undertakes, and the broadening of those able to participate in research and the related educational activities. To quote the concluding paragraph of its report:

"A new age has dawned in scientific and engineering research, pushed by continuing progress in computing, information, and communication technology, and pulled by the expanding complexity, scope, and scale of today's challenges. The capacity of this technology has crossed thresholds that now make possible a comprehensive 'cyberinfrastructure' on which to build new types of scientific and engineering knowledge environments and organizations and to pursue research in new ways and with increased efficacy. Increasingly, new types of scientific organizations and support environments for science are essential, not optional, to the aspirations of research communities and to broadening participation in those communities. They can serve individuals, teams, and organizations in ways that revolutionize what they can do, how they do it, and who participates. This vision has profound broader implications for education, commerce, and social good."[5]

Clearly, cyberinfrastructure is not only reshaping but actually creating new paradigms for science and engineering research, training, and application. Once the microprocessor was imbedded in instrumentation, Moore's Law took over scientific investigation. The availability of powerful new tools such as computer simulation, massive data repositories, massively ubiquitous sensor arrays, and high-bandwidth communication are allowing scientists and engineers to shift their intellectual activities from the routine analysis of data to the creativity and imagination to ask entirely new questions. Today, information technology has created, in effect, a new modality of scientific investigation through simulation of natural phenomenon and serving as the bridge between experimental observation and theoretical interpretation. Globalization is a particularly important consequence of the new forms of scientific collaboration enabled by cyberinfrastructure, which is allowing scientific collaboration and investigation to become increasingly decoupled from traditional organizations (e.g., research universities and corporate R&D laboratories) as new communities for scholarly collaboration evolve.

While promising significant new opportunities for scientific and engineering research and education, the digital revolution will also pose considerable challenges and drive profound transformations in existing organizations such as universities, national and corporate research laboratories, and funding agencies. Here it is important to recognize that the implementation of such new technologies involve social and organizational issues as much as they do technology itself. Achieving the benefits of IT

investments will require the co-evolution of technology, human behavior, and organizations.

Although the domain-specific scholarly communities, operating through the traditional bottom-up process of investigator-proposed projects, should play the lead role in responding to the opportunities and challenges of new IT-enabled research and education, there is a clear need to involve and stimulate as well those organizations that span disciplinary lines and integrate scholarship and learning. Perhaps the most important such organization is the research university, which despite the potential of new organizational structures, will continue to be the primary institution for educating, developing, and financing the American scientific and engineering enterprise. Furthermore, because the contemporary research university not only spans the full range of academic disciplines but as well as the multiple missions of education, scholarship, and service to society, it can–indeed, it must–serve as the primary source of the threads that stitch together the various domain-focused efforts.

There is a sense among many in the research university community that we will see a convergence and standardization of the cyberinfrastructure necessary for state-of-the-art research and learning over the next several years, built upon open source technologies, standards, and protocols, and that the research universities themselves will play a leadership role in creating these technologies, much as they have in the past. For the IT-driven transformation of U.S. science and engineering to be successful, it must extend beyond the support of investigators and projects in domain-specific science and engineering research to include parallel efforts in stimulating institutional capacity.

National Science Foundation Tutorial

In fall of 2004, members of the IT Forum were invited to conduct a day-long "tutorial" for the leadership of the National Science Foundation concerning the potential impact of information technology on learning, broadly defined. Forum members began by stating their concern that the changing learning needs of our society and the disruptive nature of digital technology may extend well beyond the capacity of our existing learning infrastructure of schools, universities, training programs, and cultural institutions. Approaching the challenge by reforming existing institutions may not be sufficient. After all, "a butterfly is not simply a better caterpillar!" Instead perhaps it was time to explore entirely different types of learning organizations and ecologies.

Today the human resource needs of the nation, an increasingly competitive global, knowledge-driven economy, and the challenge and promise presented by

exponentially evolving digital technology presents a new and compelling challenge to NSF to provide leadership and stimulate change in our nation's learning enterprise.

University Executive Leadership Core Workshops

One of the major concerns voiced in the workshops with the Association of American Universities presidents and provosts was the difficulty in getting universities to recognize the strategic implications of rapidly evolving digital technologies as they reshape the most fundamental aspects of learning and scholarship. Some participants portrayed the challenge to be getting the executive leadership core of the institution–the president, provost, CFO, CIO, director of libraries, key deans–on the same page, communicating with one another rather than simply dumping a diverse array of issues and demands on the CIO and saying, "Handle it!"

To this end they suggested that the IT Forum conduct a series of roundtable workshops around the country, bringing together the executive leadership of several institutions in a facilitated roundtable discussion to compare notes on what they saw as challenges and opportunities. The hope was that engaging in a candid and confidential discussion with peer institutions would force each of the participating teams to get their act together. They would learn from each other and perhaps develop the basis for further collaboration.

Over the course of the 2004-2005 academic year, the IT Forum organized four such workshops:

Cambridge (September 1-2, 2004): CEO-led teams from Carnegie-Mellon University, Cornell University, and Massachusetts Institute of Technology

Chapel Hill (January 24-25, 2005): CEO-led teams from North Carolina State University and the University of North Carolina at Chapel Hill, an Executive Vice Chancellor-led team from Duke University, and individual leaders from Georgia Institute of Technology and the University of Maryland

Austin (March 21-22, 2005): CEO-led teams from Texas A&M University, the University of Arizona, and the University of Texas at Austin, and individual leaders from Arizona State University and Rice University

Irvine (April 25-26, 2005): CEO-led teams from the University of California, San Diego, the University of California, Santa Barbara, and the University of Southern California, an Executive Vice Chancellor-led team from the University of California, Los Angeles, and an individual leader from the University of California, Irvine.

The purpose of these workshops were: i) to help university leadership identify the key challenges and opportunities presented by emerging information technology by comparing perspectives with several peer institutions; ii) to help the executive leadership of a university get on the same page in developing institutional strategies; and iii) to explore how to build stronger coalitions of universities working together to address these challenges.

The workshops were organized in a roundtable format developed by Robert Zemsky, former chair of the Pew Higher Education Roundtable and now director of the Learning Alliance at the University of Pennsylvania, who also served as the moderator for these sessions. Such a roundtable process is particularly effective in encouraging broad and candid engagement of all participants. Each workshop was launched with a working dinner the evening before a day-long workshop, asking each of the presidents to begin the conversation by describing what excited and what scared them about rapidly evolving digital technology. Needless to say, the fears tended to outnumber the hope.

Not surprisingly, several presidents immediately brought up the challenge of managing unbridled expectations for the IT environment. Their faculties believed that "bandwidth should flow like water from a faucet". These university leaders worried that they would be unable to afford the IT investments necessary to stay on the cutting edge of research while meeting ever-expanding student expectations and eventually fall behind, unable to compete for the best faculty and students. Several also expressed concern about the difficulty of making the right decisions on investments, e.g., knowing whether they were headed in the right direction or toward a wall (or a cliff). There was a sense of dread because of the uncertainty and the implications of a bad decision, in terms of cost, the quality of the environment or teaching and research, and even the ability of the institution to function. As one president put it, "I worry that one day I will come into work and find that absolutely nothing works."

Such concerns usually led rapidly to a discussion of the increasing challenge in maintaining the security of the IT infrastructure. Some participants even suggested that

a failure in this area could lead to the entire enterprise grinding to a halt, or that a severe attack launched through a university and impacting broader society might result in civil or even criminal liability. Although several of the CIOs agreed that this problem was solvable with sufficient standards and controls, frequently these were incompatible with the diversity–indeed, anarchy–characterizing the many computing environments and student and faculty cultures in the university.

One of these evening dinner discussions was dominated by a conversation on the degree to which students were beginning to use technology both to seize control of their learning environments and to drive change within the institution, much as the IT Forum had found in the workshop at Carnegie-Mellon University. The student social life and learning activities were increasingly structured around always-on, always-in-contact communication (wireless, e-mail, instant messaging). In contrast to the student isolation that some predicted as a consequence of the propagation of technology into the university, there is a zeal for contact and community building among students, demanding not only an ever more sophisticated IT environment, but as well the convenience and responsiveness of university services and instructional activities that students were accustomed to in the commercial arena (Amazon, Google, e-Bay, Travelocity, etc.) Students were beginning to form communities capable of learning on their own and challenging the one faculty member-one course paradigm.

Yet at most institutions, these new IT-based social organizations were quite beyond the comprehension of the faculty, many of whom would just as soon ban wireless connectivity from the classroom and restrict students to using 110 bits-per-second modems to slow things down. While several participants questioned the effectiveness of this highly interactive, multi-tasking, and rapid context switching approach to learning, others suggested it might actually be the best preparation for leadership roles in the very complex, fast- moving social situations of 21st century society.[6] Yet this not only raised the challenge of keeping up with the kids as they became less and less tolerant of traditional approaches to higher education, but it also raised the question of the role that the faculty would play, e.g., leading, lagging, or just staying out of the way.

Such discussions usually converged on recognition that the rapid evolution of digital technology was not only creating a very complex environment for leadership, but that it was characterized by chaos, in which the predictability of decisions and actions became very difficult if not impossible. Efforts to exert the top-down controls demanded by network security and integrity sometimes seemed like trying to close the barn door after the horse had not only already escaped, but the barn itself had fallen down. Several

of these evening conversations even suggested that the traditional organization, structure, management, and leadership of the university might be inadequate to deal with such a rapidly evolving and changing technology. At this point, we usually called it an evening, and adjourned to the next day for more in-depth discussions of particular issues of interest to the participants.

Managing Change

The primary issue arising in discussions of managing the IT environment involved the balance between the centralized control and standardization necessary to achieve adequate connectivity and security, and the inevitable chaos that characterizes the university IT environment because of highly diverse needs and funding sources–particularly in the research arena. There needs to be a balance between infinite customizability and institution-wide standards that protect the organization. There is a need to tolerate freedom–indeed, anarchy–in some domains such as research, while demanding tight control and accountability in others such as telecommunications and financial operations. Of course, this is similar to the struggle between the centralization (security, interoperability) and the decentralization (creativity, unique needs) in all organizations–universities, governments, and corporations.

There was also considerable discussion of just where universities should focus their resources and attention. Some universities felt that the best approach was to outsource the stable infrastructure, including mission-critical services such as finance and telecommunications, and focus attention instead on advanced development efforts, particularly those involving consortia such as Open Knowledge Initiative and Sakai[7]. It is important to select what you can manage, and what you can let go, to pick those areas where you can see strategic opportunities for influence. Outsourcing commodity products and services can allow institutions to free up resources for investing in the future.

Although some institutions were still striving for centralized control, most had recognized that heterogeneity was a fact of life that needed to be both tolerated and supported. It was important to move beyond the contrasts between academic and administrative IT and instead recognize the great diversity of needs among different missions such as instruction, research, and administration as well as among early adopters, mainstream users, and have-nots. The faculty seeks both a reliable platform (a utility) as well as the capacity to support specific needs; researchers would frequently just as soon the administration kept hands off, since their grants are paying for their IT

support. The students seek the same robust connectivity and service-orientation that they have experienced in the commodity world, and they will increasingly bring the marketplace onto the campus. In some ways, executive leadership is less a decision issue than a customer relationship management issue.

Several of the workshops featured discussions about the most important IT-related decisions made in the past few years, what issues were involved, who was involved in discussion and decision-making, and what the results were. To our ears, these decisions mainly fell into two categories. The first consisted of seeming "no-brainers," where it was necessary to get presidential approval and mobilize resources to join initiatives that were already moving forward, and where participation was clearly in the institution's long-term interest. The second category consisted of somewhat more difficult decisions where an entrenched interest within the institution had to be taken on in order to conserve resources or achieve other goals for the campus as a whole. There were initiatives that would qualify as visionary, but these were few and far between.

Several participating universities have undergone recent changes in organization or have launched standing councils or committees to address IT issues. Personnel changes have sparked some of these changes. Direct CEO-level involvement in these discussions is uncommon. One long-term trend is the increase in the number and proportion of CIOs who come from industry or other non-academic backgrounds, and the corresponding decrease in the number and proportion of CIOs who emerge from the faculty. Interestingly, participation in decision-making processes did not necessarily map on to the composition of the teams that attended the workshop. Several teams featured department heads and others from academic units, while others consisted entirely of central administrators. Overall, the message we got from all four workshops was that leading research universities believe they are doing a good job managing the IT "here and now"; that they are in control regarding the most important issues; and that a cataclysmic meltdown is not a real possibility.

The Learning Environment

Although the influence of the net generation of students was raised in early discussions, there was surprisingly little discussion of the use of IT in the instructional environment. To be sure, most participants recognized the way that technologies such as instant messaging, wireless access, and search engines such as Google were changing both the social interactions and intellectual development of students. Yet there was little discussion of how to harness these new capabilities in the learning environment.

The faculty, by and large, is not as tech savvy as students, and is not aware of the tech-infused culture in which students live and learn. In contrast to the research mission, where the faculty is pushing the boundaries and administrators are forced to respond, in these institutions at least, few faculty members seem involved in cutting-edge use of technology in the instructional domain.

However, this is an arena in which for-profit competition is appearing, where overseas competition might be expected to appear, and where U.S. universities may be in danger of being "Napsterized." The fact that students use one mode of interaction in dealing with faculty because they have to and use another mode when dealing with each other might partially reflect a longstanding intergenerational dynamic. It might also imply that traditional educational institutions are not reaching them, and they are "ripe for the picking" by some new educational institution or instructional mode.

Some participants were confident about the prospects for the optimal uses of technology emerging naturally, while others believed that institutional leaders need to be more proactive in guiding and facilitating. We are left with the questions of how leadership can recognize and leverage strategic opportunities, and how universities can collaborate and learn from one another.

The Library as the Poster Child of the IT Revolution

To make these discussions less abstract, the impact of information technology on university planning for libraries was introduced in several workshops. In a sense the library has become the poster child for the impact of IT on higher education. Beyond the use of digital technology for organizing, cataloguing, and distributing library holdings, the increasing availability of digitally-created materials and the massive digitization of existing holdings (e.g, the Google project to digitize and put online in searchable format the entire holdings of major research libraries) is driving massive change in the library strategies of universities. While most of the universities in our workshops were continuing to build libraries, many were no longer planning them as repositories (since books were increasingly placed in off-campus retrievable high-density storage facilities) but rather as a knowledge commons where users accessed digital knowledge on remote servers. When pressed, it turned out that the most common characteristic of these new libraries was a coffee shop. They were being designed as a community center where students came to study and learn together, but where books were largely absent. The library was becoming a people place, providing the tools to support learning and scholarship and the environment for social interaction.

What is the university library in the digital age? Is it built around stacks or Starbucks? Is it a repository of knowledge or a "student union" for learning? In fact, perhaps this discussion was not really about libraries at all, but rather the types of physical spaces universities require for learning communities. Just as today every library has a Starbucks, perhaps with massive digitization and distribution of library holdings, soon every Starbucks will have a library–indeed, access to the holdings of the world's libraries through wireless connectivity.

In a sense, the library may be the most important observation post for studying how students really learn. If the core competency of the university is the capacity to build collaborative spaces, both real and intellectual, then the changing nature of the library may be a paradigm for the changing nature of the university itself.

Yet the participants in our workshops also raised the very serious issue concerning the preservation of digital knowledge, now increasing at a rate an order of magnitude larger than written materials. Without a more concerted effort for the standardization of curation, archiving, and preservation of digital materials, we may be creating a hole in our intellectual history. Traditionally this has been a major role of the research university through its libraries. There was a general agreement that research universities need to collaborate more on their responsibilities for the stewardship of knowledge in the digital age.

Competition vs. Cooperation vs. Collaboration

Another workshop theme was the degree to which information technology was changing the balance between university competition and collaboration. To be sure, the competitive spirit was alive and well in those workshops involving IT leaders (e.g., MIT, Carnegie Mellon, and Cornell) as well as those with both public and private universities (e.g., the University of California and USC). Yet, just as in the earlier workshops held with presidents and provosts, there was recognition that few, if any, institutions had the capacity to go it alone in technology development and implementation, particularly in the face of monopoly pressures from the commercial section.

This growing need to build alliances was particularly apparent in the middleware and networking area. A new set of open educational resources (open-source tools, open content, and open standards) is being created by consortia such as Open Knowledge Initiative, Sakai, and the Open CourseWare project and being made available to educators everywhere. Networking initiatives led by higher education, grid

computing, and other elements of cyberinfrastructure are gaining momentum through alliances such as Internet2 and the National Lamba Rail.

Just as in the IT industry itself, there are emerging trends where universities are cooperating in areas such as cyberinfrastructure and instructional computing that allow them to compete more effectively for faculty, students, and resources. The CIOs in our workshops suggested that the growing consensus on nature IT infrastructure of research universities over the next several years–based on open-source standards and outsourcing stable infrastructure–would demand such cooperative efforts.

Leadership

How does one lead an institution through when key technologies are undergoing such order of magnitude changes? To some participants, the key was empowering the next generation of the faculty. "Our young faculty members generate the best ideas, but traditional academic structures may prevent those ideas from coming to the fore. Therefore, visionary university leadership requires the creation of ad hoc structures that empower young faculty to generate ideas, and focusing presidential attention and resources on the best ones. As long as we can attract the best young faculty, we will be able to stay on the leading edge and innovate."

While this sounded like an appropriate strategy, and the participating schools could clearly point to a number of important initiatives that have emerged in this way, we were not so convinced. Is there really is such a strong flow of innovative ideas in the IT sphere, even from the top young faculty? And if there is such a strong flow, how do leaders then decide which "horses to back" from among the many worthy candidates?

Others participants conveyed a much more skeptical discussion of leadership and governance, at least as it relates to IT. The leadership ideal expressed by one participant was "make a transformative decision, execute, and repeat." However, several participants expressed the view that the changing environment has made it difficult if not impossible for individual leaders to reach this ideal with any consistency. For example, it is more difficult than it used to be to generate a significant impact with a relatively small bet. With the current threshold at $10-$20 million, risk aversion may lead to technology investments being made in dysfunctional ways.

Also, in contrast with the faith that some participants expressed in the ideas of individual faculty as a transformative force, others were more inclined to see the faculty as a group or vested interest standing in the path of needed innovation. In this

formulation, even new ad hoc structures could not overcome the dead weight of traditional structures that are not working.

Some even suggested that neither university leaders nor even individual institutions could lead through such an era of rapid and profound change. Rather alliances must be created to provide the leadership, or the monopoly-dominaed marketplace itself will lead, perhaps in directions antithetical to the nature of the research university. It could well be that it is the leadership structure of the university itself that has become obsolete, and this is the area in most need of change. Here, one participant reminded us, a true revolution replaces all of the leadership of a society.

General Strategies

Here we found a very significant contrast between two approaches to IT management and development: the optimists, who viewed the chaos of the rapidly evolving IT environment as not only inevitable but tolerable–just let it happen, we can adapt, *hakuna matata*[8]–and the pessimists, who believed that the university needed to control and guide the IT revolution. The former group usually consisted of those institutions that had been leaders in IT development and implementation. They were confident while the revolution would continue, their institutions would remain in a leadership role. (One colleague mentioned the old proverb that one needs not outrun a tiger, but only outrun your companion…)

There was, however, general agreement about the unpredictable and occasionally disruptive nature of this technology. Some felt that the biggest threat was the frustration over constant technological change. Others suggest that folks just "get over it", since continuous change is the key characteristic of a knowledge-driven society. The chaos of IT evolution could be an asset if it stimulated more experiment. Since the marketplace might be a more effective and efficient way to allocate resources and determine priorities, some suggested that universities should strive for an ecology of experimentation and alliances.

An Assessment of the Executive Leadership Core Workshops

In looking back over the year of workshops with the executive leadership cores of 18 leading research universities, the IT Forum has several interesting observations. First, it seems clear that while most university presidents are aware of the challenges posed by rapidly evolving digital technology (their world is indeed "flat"), they do not

include it high on their lists of priorities for personal attention. Presidents are looking at IT only as a threat, not an opportunity, and they do not believe this where the wheels are likely to come off the train, as they are in other more critical areas such as state support, private fund-raising, faculty recruiting, demographic changes in the student population, or federal higher education policy where they prefer to focus attention. Besides, if IT is really an area characterized by chaos, there is little that can be controlled anyway.

This *hakuna matata* attitude is the second issue. To be sure, most of the universities involved in our workshop had long histories of adapting readily to change and sustaining leadership in areas such as technology. The richest universities may well be able to ignore these technology trends, pull up the lifeboats, and feel secure with business as usual. Yet the complacency that accompanies past success can be dangerous, as Lou Gertsner pointed out to the AAU presidents from IBM's history.

The third observation is just how difficult it was to steer these discussions in a more strategic direction, attempting to look over the horizon at the challenges and opportunities that could arise as this technology continued its inevitable progression, a 100 or 1,000 fold over the next decade. While participants would nod their heads, they soon regressed into a "we're positioned well for whatever comes, so lets get back to taking about the details of today's issues". The discussions kept coming back to concern "this is what bothers us now" rather than "where be might be ten years from now".

There was remarkably little conversation about the major changes occurring in scholarship and learning, driven in part by technology. Although there was recognition about the new IT-based communities that were evolving for faculty (e.g., cyberinfrastructure-based, global research communities) and students (e.g., social learning communities based on instant messaging), there was little discussion about how the university could take advantage of this in their educational and research missions.

There was also little evidence that these leaders understood just how rapidly this technology is driving major structural changes in other sectors such as business and government. Today an industry's CIO's life is challenged to reduce IT costs for given productivity by factors of 10 every few years. While university leaders were aware of the productivity gains enabled by a strategic use of technology in industry, they found it difficult to imagine the structural changes in the university capable of delivering such improvement.

To some degree, this unwillingness to think more deeply about the strategic implications of a technology evolving at a Moore's Law pace is evidence again of the complacency characterizing leading research universities. Their perch atop the higher

education food chain and their relative wealth leads them to continue doing things the same old way. The real challenge is to pry the leadership away from near-term decisions to focus instead on long-term strategies, on "what" you do rather than "how" you do it. We tried to ignite these discussions with provocative questions such as:

1. Suppose the digital generation were to take control of their learning environments, demanding not only the highly interactive, collaborative learning experiences but the sophistication and emotional engagement of gaming technology and the convenience of other IT-based services.

2. Imagine that the extraordinary advances in cognitive science, neuroscience, and learning theories actually began to be applied in educational practice, yielding significantly improved outcomes at lower cost. What would happen if some lower tier universities got religion and were able to offer demonstrably better educations? What would that do to their competing colleges and universities? Would the top tier emulate them?

3. If students vote with their feet (and thumbs) and their dollars, what changes would they demand? If courses based on game technology, excellent graphics, and pleasant surroundings (not 8 am in a drafty lecture hall) compete with current offerings, what changes would result?

4. Today the common thread of most university libraries is the presence of a Starbucks. What happens if the Google digitization project creates in every Starbucks access to all the world's libraries?

5. What are the deeper implications of new collaborations largely independent of the university that are enabled by cyberinfrastructure compete with traditional organizations such as the research university for the loyalty and participation of scholars.

6. Could these emerging scientific communities compete with and break apart the feudal hierarchy that has traditionally controlled scientific training (particularly doctoral and postdoctoral work), empowering young scholars and enabling greater access to scientific resources and opportunities for collaboration and engagement?

7. What is impact of cyberinfrastructure on the "culture" of scientific activities and institutions, e.g., publication, collaboration, competition, travel, and the ability of participants to assume multiple roles (master, learner, observer) in various scholarly communities, the increasing importance of creativity relative to analysis as powerful new tools of investigation (e.g., simulation, massively pervasive sensor arrays) enabled by cyberinfrastructure appear?

8. At its most abstract, the "university" is a community of masters and scholars (*universitas magistorium et scholarium*), a school of universal learning that embraces every branch of knowledge and all possible means for making new investigations and thus advancing knowledge. These two characteristics, scholarly community and breadth of both intellectual topics and tools, have remained the core elements of the various forms taken by the university from medieval times (e.g., Paris and Bologna), through the Renaissance and Enlightenment, to today's research universities. We already see these elements appearing in new forms enabled by cyberinfrastructure, e.g., global, domain-specific communities of scholars detached from traditional institutions such as universities, and exceptionally broad digital collections of knowledge such as digital libraries or the archives of search engines such as Google. Could these be the precursors of a new form of the university, essentially appearing spontaneously out of the vacuum state of the cyberspace enabled by cyberinfrastructure?

    Such questions had little traction with these leadership workshops, with their tendency to focus more on technology threats than opportunities to enhance their core missions of learning, discovery, and engagement with society.

Whence and Whither the Revolution

The report characterizing the first phase of this study of the impact of information technology on the university was entitled *Preparing for the Revolution*. But what revolution? The university today looks very much like it has for decades, still organized into academic and professional disciplines; still basing its educational programs on the traditional undergraduate, graduate, and professional discipline curricula; still financed, managed, and led as it has been for many years.

Yet if one looks more closely at the core activities of students and faculty, the changes over the past decade have been profound indeed. The scholarly activities of the faculty have become heavily dependent upon digital technology–rather cyberinfrastructure–whether in the sciences, humanities, arts, or professions. Although faculties still seek face-to-face discussions with colleagues, these have become the booster shot for far more frequent interactions over Internet. Most faculty members rarely visit the library anymore, preferring to access far more powerful, accessible, and efficient digital resources. Many have ceased publishing in favor of the increasingly

ubiquitous preprint route. Even grantsmanship has been digitized with the automation of proposal submission and review and grant management and reporting by funding agencies. And, as we have noted earlier, both student life and learning is also changing rapidly, as students bring onto campus with them the skills of the net generation for applying this rapidly evolving technology to their own interests, forming social groups, role playing (gaming), accessing services, and learning–despite the insistence of their professors that they jump through the hoops of the traditional classroom paradigm.

In one sense it is amazing that the university has been able to adapt to these extraordinary transformations of its most fundamental activities, learning and scholarship, with its organization and structure largely intact. Here one might be inclined to observe that technological change tends to evolve much more rapidly than social change, suggesting that a social institution such as the university that has lasted a millennium is unlikely to change on the timescales of tech turns–although social institutions such as corporations have learned the hard way that failure to keep pace can lead to extinction. Yet, while social institutions may respond more slowly to technological change, when they do so, it is frequently with quite abrupt and unpredictable consequences, e.g., "punctuated equilibrium". It could also be that the revolution in higher education is well underway, at least with the early adopters, and simply not sensed or recognized yet by the body of the institutions within which the changes are occurring.

Universities are extraordinarily adaptable organizations, tolerating enormous redundancy and diversity. It could be that information technology revolution is more a tsunami that universities can float through rather a tidal wave that will swamp them. One of our participants suggested that perhaps what we should view the transformation of the university as an evolutionary rather than a revolutionary process. Evolutionary change usually occurs first at the edge of an organization (an ecology) rather than in the center where it is likely to be extinguished. In this sense the cyberinfrastructure now transforming scholarship or the communications technology enabling new forms of student learning have not yet propagated into the core of the university. Of course, from this perspective, recent efforts such as the Google project take on far more significance, since the morphing of the university library from stacks to Starbucks strikes at the intellectual soul of the university.

It is certainly the case that futurists have a habit of overestimating the impact of new technologies in the near term and underestimating them over the longer term. There is a natural tendency to implicitly assume that the present will continue, just at an accelerated pace, and fail to anticipate the disruptive technologies and kill apps that turn

predictions topsy-turvy. Yet we also know that far enough into the future, the exponential character of the evolution of Moore's Law technologies such as info-, bio-, and nano- technology makes almost any scenario possible.

While perhaps not enabling the level of strategic discussions that we had hoped, the IT Forum has certainly reinforced the good-news, bad-news character of digital technology. The good news is that it works, and eventually it is just as disruptive as predicted. The bad news is the same: this stuff works, and it is just as disruptive as predicted.

In this spirit, then, perhaps we should end with a discussion that occurred with the AAU provost's workshop in 2004. While university presidents are reluctant to let speculation about the survival of the university on the table, not so with provosts, who were quite comfortable talking about very fundamental issues such as the values, roles, mission, and even the survival of the university, at least as we know it today. During this discussion it was pointed out during the 19th century, in a single generation following the Civil War, essentially everything that could change about higher education in America did in fact change: small colleges, based on the English boarding school model of educating only the elite, were joined by the public universities, with the mission of educating the working class. Federal initiatives such as the Land Grant Acts added research and service to the mission of the universities. The academy became empowered with new perquisites such as academic freedom, tenure, and faculty governance. Universities increased 10-fold and then 100-fold in enrollments. The university at the turn of century bore little resemblance to the colonial colleges of a generation earlier.

The consensus of our discussions with the provost suggested that we are well along in a similar period of dramatic change in higher education. In fact, some of our colleagues were even willing to put on the table the most disturbing question of all: Will the university, at least as we know it today, even exist a generation from now? Disturbing, perhaps. But certainly a question deserving of very careful consideration, at least by those responsible for leading and governing our institutions, suggesting that perhaps such studies should shift from "the impact of technology on the future of the research university" to "the impact of technology on scholarship and learning, wherever they may be conducted"!

Certainly the monastic character of the ivory tower is certainly lost forever. Although there are many important features of the campus environment that suggest that most universities will continue to exist as a place, at least for the near term, as digital technology makes it increasingly possible to emulate human interaction in all the

sense with arbitrarily high fidelity, perhaps we should not bind teaching and scholarship too tightly to buildings and grounds. Certainly, both learning and scholarship will continue to depend heavily upon the existence of communities, since they are, after all, high social enterprises. Yet as these communities are increasingly global in extent, detached from the constraints of space and time, we should not assume that the scholarly communities of our times would necessarily dictate the future of our universities. Even in the near term, we should again recall Christensen's *innovators's dilemma*[9], as these disruptive technologies, which initially appear rather primitive, are stimulating the appearance of entirely new paradigms for learning and research that could not only sweep aside the traditional campus-based, classroom-focused approaches to higher education but seriously challenge the conventional academic disciplines and curricula. For the longer term who can predict the impact of exponentiating technologies on social institutions such as universities, corporations, or governments, as they continue to multiply in power a thousand-, a million-, and a billion-fold?

To be sure, there will be continuing need and value for the broader social purpose of the university as a place where both the young and the experienced can acquire not only knowledge and skills, but the values and discipline of an educated mind, so essential to a democracy; an institution that defends and propagates our cultural and intellectual heritage, even while challenging our norms and beliefs; the source of the leaders of our governments, commerce, and professions; and where new knowledge is created through research and scholarship and applied through social engagement to serve society. But, just as it has in earlier times, the university will have to transform itself once again to serve a radically changing world if it is to sustain these important values and roles.

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[1] Thomas L. Friedman, *The World is Flat: A Brief History of the 21st Century* (Farrar, Strauss, and Giroux: New York, 2005).

[2] Clayton M. Christensen, *The Innovator's Dilemma* (Harvard Business School Press, Cambridge, 1997).

[3] *Preparing for the Revolution: Information Technology and the Future of the University* (Washington, D.C.: National Academies Press, 2003), www.nap.edu.

[4] Elisabeth Kubler Ross, *Death and Dying* (Simon & Schuster: New York, 1969).

[5] Daniel E. Atkins (chair), (2003). *Revolutionizing Science and Engineering Through Cyberinfrastructure*, Report of the National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure. National Science Foundation, Washington, DC.

[6] John Seely Brown and Paul Duguid, *The Social Life of Information* (Harvard Business School Press: Cambridge, 2000).

[7] The Open Knowledge Initiative is an effort to develop the open source protocols for developing software modules for the support of higher education. Sakai is multi-university (led by U. Michigan, MIT, Stanford, and U. Indiana) to develop the middleware environment for open source software to support instruction, scholarship, and university enterprise applications. Both are aimed at creating university alliances for innovation and rapid prototyping of open source software for higher education.

[8] *Hakuna Matata*, Swahili for "not to worry" (and the title of a popular song from Disney's *The Lion King*)

[9] Clayton M. Christensen, *The Innovator's Dilemma* (Harvard Business School Press, Cambridge, 1997).