Sigma Xi Forum Notes

A Word about the University of Phoenix

Phoenix targets the educational needs of adult learners whose career and family responsibilities make access to traditional colleges and universities difficult. By relying on highly structured courses formatted for the students convenience, and taught by practitioners as part-time instructors, Phoenix has developed a highly competitive paradigm.

It is important to recognize that while competitors such as Phoenix and Unext.com are quite different than traditional academic institutions, they are also quite sophisticated both in their pedagogy, their instructional materials, and their production and marketing of educational services. Most of these new entrants such as the are focusing on the adult education market. Some, such as Unext.com, have aggressive growth strategies beginning first with addressing the needs for business education of corporate employees but then migrating rapidly up the academic value chain. They are investing heavily (over $100 million in 2000) in developing sophisticated instructional content, pedagogy, and assessment tools, and they are likely to move up the learning curve to offer broader educational programs, both at the undergraduate level and in professional areas such as engineering and law. In a sense, therefore, the initial focus of new for-profit entrants on low-end adult education is misleading, since in five years or less their capacity to compete with traditional colleges and universities could be formidable indeed.

Although traditional colleges and universities will also play a role in such a technology-based, market-driven future, they could both threatened and reshaped by shifting societal needs, rapidly evolving technology, and aggressive for-profit entities and commercial forces. To be sure, many of the predictions about the growth of demand for distance learning are overly optimistic, at least for the near term. But clearly the university is losing its monopoly for students, faculty, and resources, and it is likely to lose market share as well as commercial competitors position themselves to address the rapidly growing needs for adult education. The successful penetration of this market for most universities will involve partnerships with the commercial sector.

The research university will face particular challenges in this regard. Although rarely acknowledged, most research universities rely upon cross-subsidies from low-cost, high profit-margin instruction in general education (e.g., large lecture courses) and low cost professional education (e.g., business administration and law) to support

graduate education and research. Yet these high margin programs are just the low hanging fruit most attractive to technology-based, for-profit competitors. In this sense, the emergence of a significant technology-based commercial sector in the post-secondary education marketplace could undermine the current business model of the research university and threaten its core activities in research and graduate education.

A National Academy Project

Last year (2000) the presidents of the National Academies (Science, Engineering, and Medicine) launched a major new study to explore the impact of information technology on the future of the research university, which I was asked to chair. The premise is 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 is an increasing 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 project, organized under the Government-University-Industry Research Roundtable (GUIRR), was aimed at addressing three sets of issues:

- To identify those technologies likely to evolve in the near term (a decade or less) which could have major impact on the research university.

- To examine the possible implications of these technology scenarios for the research university: its activities (teaching, research, service, outreach); the organization, structure, management, financing of the university; and the impact on the broader higher education enterprise and the environment in which it functions.

- To determine what role, if any, there is for the federal government and other stakeholders in the development of policies, programs, and investments to protect the valuable role and contributions of the university during this period of change.

To this end, a Steering Committee to guide the project was formed last year consisting of leaders drawn from industry, higher education, and government with expertise in the areas of information technology, research universities, and public policy.

Since first convening in February 2000, the Steering Committee has held several meetings (including site visits to major technology development centers such as Lucent (Bell) Laboratories and IBM Research Laboratories) and held numerous conference calls to identify and discuss trends, issues, and possible recommendations. The key themes addressed by these activities were:

- The pace of evolution of information technology (e.g., Moore's Law).
- The ubiquitous/pervasive character of the Internet (e.g., wireless, photonics).
- The relaxation (or obliteration) of the conventional constraints of space, time, and monopoly.
- The democratizing character of IT (access to information, education, research).
- The changing ways we handle digital data, information, and knowledge.
- The growing importance of intellectual capital relative to physical or financial capital

In January 2001 a two-day workshop was held at the National Academies with invited participation of over 100 leaders from technology, higher education, and government. The purpose of the workshop was to stimulate a conversation, to launch a dialog, aimed at identifying key themes and issues, to suggest possible recommendations and strategies for research universities and their various stakeholders, and to provide guidance on the next phase of the project. The key presentations and discussion of the workshop were videotaped and broadcast on the Research Channel and video-streamed from its website during the spring to serve as an archive for further discussion.

Although the project is still in an early phase, there are already some important preliminary conclusions:

1. The extraordinary evolutionary pace of information technology is not only likely to continue for the next several decades, but it could well accelerate on a superexponential slope. Photonic technology is evolving at twice the rate of silicon chip technology (e.g., Moore's Law), with miniaturization and wireless technology moving even faster, implying that the rate of growth of network appliances will be incredible. For planning purposes, we can assume that within the decade we will have infinite bandwidth and infinite processing power (at least compared to current capabilities).

   For the first several decades of the information age, the evolution of hardware technology followed the trajectory predicted by "Moore's Law"—a 1965

observation/prediction by Intel founder Gordon Moore that the chip density and consequent computing power for a given price doubles every eighteen months.[i] Although this was intended to describe the evolution of silicon-based microprocessors, it turns out that almost every aspect of digital technology has doubled in power roughly every 12 to 18 months, with some technologies such as optical computing, telecommunications, and wireless technology increasing even more rapidly. Put another way, digital technology is characterized by the extraordinary pace of evolution in which characteristics such computing speed, memory, and network transmission speeds for a given price increase by a factor of 100 to 1000 every decade.

The most dramatic impact on our world today from information technology is not in the continuing increase in computing power. It is in a dramatic increase in bandwidth, the rate at which we can transmit digital information. Fiber optics cable is currently being installed throughout the world at the astounding equivalent rate of over 3,000 mph! In a sense, the price of data transport is becoming zero, and with rapid advances in photonic and wireless technology, telecommunications will continue to evolve very rapidly for the foreseeable future.

The nature of human interaction with the digital world—and with other humans through computer-mediated interactions—is evolving rapidly. We have moved beyond the simple text interactions of electronic mail and electronic conferencing to graphical-user interfaces (e.g., the Mac or Windows world) to voice to video. With the rapid development of sensors and robotic actuators, touch and action at a distance will soon be available. The world of the user is also increasing in sophistication, from the single dimension of text to the two-dimensional world of graphics to the three-dimensional world of simulation and role-playing. With virtual reality, it is likely that we will soon communicate with one another through simulated environments, through "telepresence," perhaps guiding our own software representations, our digital agents, to interact in a virtual world with those of our colleagues.

This is a very important point. A communications technology that increases in power by 100-fold decade after decade will soon allow human interaction with essentially any degree of fidelity we wish—3-D, multimedia, telepresence,

perhaps even directly linking our neural networks into cyberspace, à la Neuromancer,[ii] a merging of carbon and silicon.

By next year over 90% of homes and 98% of schools in the United States will be linked into the Internet. Already the Internet links together hundreds of millions of people. It is estimated that there will be over 1.5 billion net-enabled cellular phones or PDAs ("personal digital appliances" such as the Palm Pilot) by 2004. Already the Internet links together hundreds of millions of people, and estimates are that within a few years, this number will surge to billions, a substantial fraction of the world's population, driven in part by the fact that most economic activity will be based on digital communication.

Put another way, over the next decade, we will evolve from "giga" technology (in terms of computer operations per second, storage, or data transmission rates) to "peta" technology (one million-billion or 10^{15})[iii]. We will denominate the number of computer servers in the billions, digital sensors in the tens of billions, and software agents in the trillions. The number of people linked together by digital technology will grow from millions to billions. We will evolve from "e-commerce" and "e-government" and "e-learning" to "e-everything"!

2. The event horizons are moving ever closer. Getting people to think about the implications of accelerating technology learning curves as well as technology cost-performance curves is very important. There are likely to be major technology surprises, comparable in significance to the PC in 1980 and the Internet browser in 1994, but at more frequent intervals. The future is becoming less certain.

3. The impact of information technology on the university will likely be profound, rapid, and discontinous–just as it has been and will continue to be for the economy, our society, and our social institutions (e.g., corporations, governments, and learning institutions). It will affect our activities (teaching, research, outreach), our organizations (academic structure, faculty culture, financing and management), and the broader higher education enterprise as it evolves into a global knowledge and learning industry.

4. For at least the near term, meaning a decade or less, the research university will continue to exist in much its present form, although meeting the challenge of emerging competitors in the marketplace will demand significant changes in how we teach, how we conduct scholarship, and how our institutions are financed. Universities must anticipate these forces, develop appropriate strategies, and make adequate investments if they are to prosper during this period.

5. Over the longer term, the basic character and structure of the research university may be challenged by the IT-driven forces of aggregation (e.g., new alliances, restructuring of the academic marketplace into a global learning and knowledge industry) and disaggregation (e.g., restructuring of the academic disciplines, detachment of faculty and students from particular universities, decoupling of research and education).

6. Procrastination and inaction are the most dangerous courses for colleges and universities during a time of rapid technological change. To be sure, there are certain ancient values and traditions of the university that should be maintained and protected, such as academic freedom, a rational spirit of inquiry, and liberal learning. But, just as in earlier times, the university will have to transform itself to serve a radically changing world if it is to sustain these important values and roles.

7. Although we feel confident that information technology will continue its rapid evolution for the foreseeable future, it is far more difficult to predict the impact of this technology on human behavior and upon social institutions such as the university. It is important that higher education develop mechanisms to sense the changes that are being driven by information technology and to understand where these forces may drive the university.

8. Because of the profound yet unpredictable impact of this technology, it is important that institutional strategies include : 1) the opportunity for experimentation, 2) the formation of alliances both with other academic institutions as well as with for-profit and government organizations, and 3) the development of sufficient in-house expertise among the faculty and staff to track technological trends and assess various courses of action.

9. In summary, for the near term (meaning a decade or less), we anticipate that information technology will drive comprehensible if rapid, profound, and discontinuous change in the university. For the longer term (two decades and beyond), all bets are off. The implications of a million-fold increase in the power of information technology are difficult to even imagine, much less predict.

Brave, New World

The market forces unleashed by technology and driven by increasing demand for higher education are very powerful. If allowed to dominate and reshape the higher education enterprise, we could well find ourselves facing a brave, new world in which some of the most important values and traditions of the university fall by the wayside. While the commercial, convenience-store model of the University of Phoenix may be a very effective way to meet the workplace skill needs of some adults, it certainly is not a paradigm that would be suitable for many of the higher purposes of the university. As we assess these market-driven emerging learning institutions, we must bear in mind the importance of preserving the ability of the university to serve a broader public purpose. While universities teach skills and convey knowledge, they also preserve and convey our cultural heritage from one generation to the next, perform the research necessary to generate new knowledge, serve as constructive social critics, and provide a broad array of knowledge-based services to our society, ranging from health care to technology transfer.

Furthermore, our experience with market-driven, media-based enterprises has not been altogether positive. The broadcasting and publication industries suggest that commercial concerns can lead to mediocrity, an intellectual wasteland in which the lowest common denominator of quality dominates. For example, although the campus will not disappear, the escalating costs of residential education could price this form of education beyond the range of all but the affluent, relegating much if not most of the population to low-cost (and perhaps low-quality) education via shopping mall learning centers or computer-mediated distance learning. In this dark, market-driven future, the residential college campus could well become the gated community of the higher education enterprise, available only to the rich and privileged.

Of course, this dark future is the great fear of those who deplore and resist the widespread deployment of information technology in higher education. Yet the potential of this technology and the educational needs of our society are too great to ignore. Hiding our heads in the sand will not slow the pace of technological change. Nor

should we feel comfortable if some elite colleges and universities long concerned with educating only the best and brightest decide to sit this one out, using their vast wealth to continue to sustain the status quo in teaching and scholarship while ignoring the needs of a nation (not to mention a world) for advanced education. Such is particularly the case for our nation's research universities.

To be sure, it would be both unrealistic and inappropriate for our research universities to abandon their critical roles in elite education and scholarship to become heavily involved in the universal education, the ubiquitous education, needed by our society. Furthermore, the market for educational services will be broad and diverse, and the brand name for exceptional quality characterizing these institutions will still carry considerable value.

Yet throughout most of history of higher education in America, these same institutions have been the leaders for the broader enterprise. They have provided the faculty, the pedagogy, the textbooks and scholarly materials, and the standards for all of higher education. They have maintained a strong relationship and relevance to the rest of the enterprise, even though they were set apart in role and mission. Yet, as the rest of the enterprise changes, there is a risk that if the research university becomes too reactionary and tenacious in its defense of the status quo, it could well find itself increasingly withdrawn and perhaps even irrelevant to the rest of higher education in America and throughout the world.

Perhaps a more constructive approach would be to apply the extraordinary intellectual resources of the research university to assist the broader higher education enterprise in its evolution to new learning forms. Although the research universities may not be appropriate for direct involvement in mass or universal education, they certainly are capable of providing the templates, the paradigms, that others could use. They have done this before in other areas such as health care, national defense, and the Internet. To play this role, the research university must be prepared to participate in experiments in creating possible futures for higher education.

The Values and Roles of the University

In exploring possible and identifying desirable future for higher education, it is important that we bear in mind the ancient values, traditions, and roles of the university. For a thousand years the university has benefited our civilization as a learning community where both the young and the experienced could acquire not only

knowledge and skills, but the values and discipline of the educated mind. It has defended and propagated our cultural and intellectual heritage, while challenging our norms and beliefs. It has produced the leaders of our governments, commerce, and professions. It has both created and applied new knowledge to serve our society. And it has done so while preserving those values and principles so essential to academic learning: the freedom of inquiry, an openness to new ideas, a commitment to rigorous study, and a love of learning.[iv]

But there are new demands on higher education that should also be considered as possible elements of future scenarios for the university. Just as other social institutions, it has become clear that our universities simply must become more focused on those we serve. We must transform ourselves from faculty-centered to learner-centered institutions, becoming more responsive to what our students need to learn rather than simply what our faculties wish to teach. Society will also demand that we become far more affordable, providing educational opportunities within the resources of all citizens. Whether this occurs through greater public subsidy or dramatic restructuring of the costs of higher education, it seems increasingly clear that our society—not to mention the world—will no longer tolerate the high-cost, low-productivity paradigm that characterizes much of higher education in America today.

In an age of knowledge, the need for advanced education and skills will require both a personal willingness to continue to learn throughout life and a commitment on the part of our institutions to provide opportunities for lifelong learning. The concept of student and alumnus will merge. Our highly partitioned system of education will blend increasingly into a seamless web, in which primary and secondary education; undergraduate, graduate, and professional education; on-the-job training and continuing education; and lifelong enrichment become a continuum.

Already we see new forms of pedagogy: asynchronous (anytime, anyplace) learning that utilizes emerging information technology to break the constraints of time and space, making learning opportunities more compatible with lifestyles and career needs; and interactive and collaborative learning appropriate for the digital age, the plug-and-play generation. The great diversity characterizing higher education in America will continue, as it must to serve an increasingly diverse population with diverse needs and goals.

It is clear that the access to advanced learning opportunities is not only becoming a more pervasive need, but it could well become a defining domestic policy issue for a knowledge-driven society. Higher education must define its relationship with these

emerging possibilities in order to create a compelling vision for its future as it enters the next millennium

The Darwinian World of Digital Technology

The digital age poses many challenges and opportunities for the contemporary university. For most of the history of higher education in America, we have expected students to travel to a physical place, a campus, to participate in a pedagogical process involving tightly integrated studies based mostly on lectures and seminars by recognized experts. Although our faculty members have long been engaged in international scholarly communities, the locus of their personal scholarly communities have usually been the campus. Yet, as the constraints of time and space—and perhaps even reality itself—are relieved by information technology, will the university as a physical place continue to hold its relevance?

In the near term it seems likely that the university as a campus, a community of scholars and a center of culture, will remain. Information technology will be used to augment and enrich the traditional activities of the university, in much their traditional forms. To be sure, the current arrangements of higher education may shift. For example, students may choose to distribute their college education among residential campuses, commuter colleges, and online or virtual universities. They may also assume more responsibility for and control over their education. The scholarly activities of faculty will more frequently involve activities that use technology to access both distant resources and interact with colleagues around the world. The boundaries between the university and broader society will fade, just as its many roles will become ever complex and intertwined with those of other components of the knowledge and learning enterprise.

Although the digital age will provide a wealth of opportunities for the future, we must take great care not simply to extrapolate the past, but instead to examine the full range of possibilities for the future. There is clearly a need to explore new forms of learning and learning institutions that are capable of sensing and understanding the change and of engaging in the strategic processes necessary to adapt or control it. While we may successfully predict near-term evolution of information technology, it is far more difficult to predict its impact on society and its institutions. All we can say is that this technology has proven to be disruptive in character for other sectors of our society. It has driven rapid, significant, and frequently discontinuous and unpredictable change.

No one knows what this profound alteration in the fabric of our world will mean, both for academic work and for our entire society. As William Mitchell, dean of

architecture at MIT, stresses, "the information ecosystem is a ferociously Darwinian place that produces endless mutations and quickly weeds out those no longer able to adapt and compete. The real challenge is not the technology, but rather imagining and creating digitally mediated environments for the kinds of lives that we will want to lead and the sorts of communities that we will want to have."[v] It is vital that we begin to experiment with the new paradigms that this technology enables. Otherwise, we may find ourselves deciding how the technology will be used without really understanding the consequences of our decisions.

To be sure, information technology poses certain risks to the university. It will create strong incentives to standardize higher education, perhaps reducing it to its lowest common denominator of quality. It could dilute our intellectual resources and distribute them through unregulated agreements between faculty and electronic publishers. It will almost certainly open up the university to competition, both from other educational institutions as well as from the commercial sector. But it will also present extraordinary opportunities. Information technology is rapidly becoming a liberating force in our society, not only freeing us from the mental drudgery of routine tasks, but also linking us together in ways we never dreamed possible, overcoming the constraints of space and time. Furthermore, the new knowledge media enables us to build and sustain new types of learning communities, free from the constraints of space and time. This technology will democratize and distribute more broadly access to the unique resources of the university for teaching and scholarship. Higher education must define its relationship with these emerging possibilities in order to create a compelling vision for its future as it enters the next millennium.[vi]

It is our collective challenge as scholars, educators, and academic leaders to develop a strategic framework capable of understanding and shaping the impact that this extraordinary technology will have on our institutions. We are on the threshold of a revolution that is making the world's accumulated information and knowledge accessible to individuals everywhere, a technology that will link us together into new communities never before possible or even imaginable. This has breathtaking implications for education, research, and learning and, of course, for the university in the digital age.

A Word about the Digital Divide

Here it seems appropriate at this point to make one further comment concerning "the digital divide", the concern many have about a widening gap between those who can afford access to information technology and those who cannot. Such stratification in our society among the haves and have-nots would be of great concern if information technology were not evolving so rapidly. However, this technology is migrating rapidly toward "thin client" systems, in which the personal computer becomes an inexpensive and ubiquitous commodity available to anyone and everyone like today's calculator or telephone, while the real investment occurs in the supporting network infrastructure.

In reality, the concern should not be with the digital divide, but rather with the growing gap in prosperity, power, and social well-being between those who have access to quality education and those who do not, because of economic circumstances, jobs, families, or location. From this perspective, the development of technology-based methods for delivering educational services such as asynchronous learning networks and virtual universities may actually narrow the educational gap by providing universal access to quality educational opportunities. To the degree that technologies such as the Internet extend access to knowledge and learning, we might view digital technology as a "democratizing" force, extending educational opportunities to those currently underserved by traditional colleges and universities.

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[i] Peter J. Deming and Robert M. Metcalf, *Beyond Calculation: The New Fifty Years of Computing* (New York: Springer-Verlag, 1997).

[ii] William Gibson, *Neuromancer* (New York: Ace, 1984).

[iii] Put another way, a petabyte of data is roughly equivalent to the capacity of a stack of CD-ROMs nearly 2 km high.

[iv] Werner Z. Hirsch and Luc E. Weber, "The Glion Declaration: The University at the Millennium", *The Presidenc3y*, Fall, 1998 (American Council on Education, Washington) p. 27

[v] William J. Mitchell, *City of Bits: Space, Place, and the Infobahn* (Cambridge: MIT Press, 1995), <http://www-mitpress.mit.edu/City_of_Bits>.

[vi] James J. Duderstadt, *A University for the 21st Century* (University of Michigan Press, Ann Arbor, 2000).