

The Future of the Research University in the Digital Age

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Washington, D.C.
April 22, 2001

“The impact of information technology will be even more radical than the harnessing of steam and electricity in the 19th century. Rather it will be more akin to the discovery of fire by early ancestors, since it will prepare the way for a revolutionary leap into a new age that will profoundly transform human culture.”

—Jacques Attali, *Millennium*¹

Introduction

Today our society and our social institutions are being reshaped by the rapid advances in information technology: computers, telecommunications, and networks. Modern digital technologies have increased vastly our capacity to know and to do things and to communicate and collaborate with others. They allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways. This technology allows us to form and sustain communities for work, play, and learning in ways unimaginable just a decade ago. Information technology changes the relationship between people and knowledge. And it is likely to reshape in profound ways knowledge-based institutions such as our colleges and universities.

Of course higher education has already experienced significant change driven by information technology. Our management and administrative processes are heavily dependent upon this technology, as the millions of dollars our institutions spent preparing for the date reset of Year 2000 made all too apparent. Research and scholarship depend heavily upon information technology, for example, the use of computers to simulate physical phenomena, networks to link investigators in virtual laboratories or “collaboratories,” or digital libraries to provide scholars with access to knowledge resources. There is an increasing sense that new technology will also have a profound impact on teaching, freeing the classroom from the constraints of space and time and enriching the learning of our students through access to original materials.

Yet, while this technology has the capacity to enhance and enrich teaching and scholarship, it also poses certain threats to our colleges and universities. We can now use powerful computers and networks to deliver educational services to anyone, anyplace, anytime, no longer confined to the campus or the academic schedule. Technology is creating an open learning environment in which the student has evolved into an active learner and consumer of educational services, stimulating the growth of powerful market forces that could dramatically reshape the higher education enterprise.

Today we are bombarded with news concerning the impact of information technology on the market place, from “e-commerce” to “edutainment” to “virtual universities” and “I-campuses”. The higher education marketplace has seen the entrance of hundreds of new competitors that depend heavily upon information technology. Examples include the University of Phoenix, the Caliber Learning Network, Sylvan Learning Systems, the Open University, the Western Governors University, and a growing array of “dot-coms” such as Unext.com and Blackboard.com. It is important to recognize that while many of these new competitors are quite different than traditional academic institutions, they are also quite sophisticated in their pedagogy, their instructional materials, and their production and marketing of educational services. They approach the market in a highly sophisticated manner, first moving into areas characterized by limited competition, unmet needs, and relatively low production costs, but then moving rapidly up the value chain to more sophisticated educational programs. These IT-based education providers are already becoming formidable competitors to traditional postsecondary institutions.

Today many suggest that in the face of rapidly evolving technology and emerging competition, the very survival of the university, at least as we know it, may be at risk. In an interview in *Forbes* several years ago, Peter Drucker suggested: “Thirty years from now the big university campuses will be relics. Universities won’t survive. It is as large a change as when we first got the printed book.”² William Wulf, President of the National Academy of Engineering, posed the question in a somewhat different way: “Can an institution such as the university which has existed for a millennium and become an icon of our social fabric disappear in just a few decades because of technology? If you doubt it, just check on the state of the family farm.”³

Ray Kurzweil, in his provocative speculation about the future, *The Age of the Spiritual Machine*, predicts that over the next decade intelligent courseware will emerge as a common means of learning, with schools increasingly relying on software approaches, leaving human teachers to attend primarily to issues of motivation, psychological well-being, and socialization.⁴ Eventually, in two or three decades, Kurzweil sees human learning accomplished primarily by using virtual teachers and enhanced by widely available neural transplants.

While most believe the university will survive the digital age, few deny that it could change dramatically in form and character. Knowledge is both a medium and a product of the university as a social institution. Hence it is reasonable to suspect that a technology that is expanding our ability to create, transfer, and apply knowledge by

factors of 100 to 1,000 every decade will have a profound impact on the both the mission and the function of the university.

Clearly, the digital age poses many challenges and presents many 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. As the constraints of time and space—and perhaps even reality itself—are relaxed by information technology, will the university as a physical place continue to hold its relevance?

More generally, are we entering just another period of evolution for the university? Or will the dramatic nature and compressed time scales characterizing the technology-driven changes of our time trigger a process more akin to revolution in higher education? Will a tidal wave of technological, economic, and social forces sweep over the academy, both transforming the university in unforeseen and perhaps unacceptable ways while creating new institutional forms to challenge both our experience and our concept of the university?

To address these questions, I have organized my speculative remarks into three layers. First I will discuss the impact of information on the fundamental activities of the university, teaching and scholarship. Next I will consider its impact on the structure and form of the university. Finally I would like to offer some observations concerning the impact on the broader post-secondary education enterprise.

However, before discussing the future of the university in the digital age, it seems appropriate to provide first some background concerning how this technology is transforming our economy, our society, and our world.

The Evolution of Information Technology

It is difficult to understand and appreciate just how rapidly information technology is evolving. Four decades ago, one of the earliest computers, ENIAC, stood 10 feet tall, stretched 80 feet wide, included more than 17,000 vacuum tubes, and weight about 30 tons. (We have 10% of ENIAC on display as an artifact in the lobby of the computer science department at Michigan.) Today you can buy a musical greeting card with a silicon chip more powerful than ENIAC. Already a modern \$1,000 notebook computer has more computing horsepower than a \$20 million supercomputer of the early 1990s. For the first several decades of the information age, the evolution of hardware technology followed the trajectory predicted by “Moore’s Law”—that the chip

density and consequent computing power for a given price doubles every eighteen months.⁵ This corresponds to a hundredfold increase in computing speed, storage capacity, and network transmission rates every decade. . Of course, if information technology is to continue to evolve at such rates, we will likely need not only new technology but even new science. But with emerging technology such as quantum computing, molecular computers, and biocomputing, there is significant possibility that Moore's Law will continue to hold for at least a few more decades.

To put this statement in perspective, if information technology continues to evolve at its present rate, by the year 2020, the thousand-dollar notebook computer will have a computing speed of 1 million gigahertz, a memory of thousands of terabytes, and linkages to networks at data transmission speeds of gigabits per second. Put another way, it will have a data processing and memory capacity roughly comparable to the human brain.⁶ Except it will be so tiny as to be almost invisible, and it will communicate with billions of other computers through wireless technology.

This last comment raises an important issue. 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. From the 300 bits-per-second modems of just a few years ago, we now routinely use 10-100 megabit-per-second local area networks in our offices and houses. Gigabit-per-second networks now provide the backbone communications to link local networks together, and with the rapid deployment of fiber optics cables and optical switching, terabit-per-second networks are just around the corner. 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.

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}). 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"!

More specifically, IBM estimates that by 2004 there will be over 1.3 billion net-enabled cellular phones or personal digital appliances (e.g., Palm Pilots) in the world.⁷ In fact, almost everyplace in the world will have robust wireless access to the Internet-

except for the United States, where our continued reliance on traditional telephone networks and our archaic practices and regulations have limited the growth in wireless technology. Estimates are that by the end of the decade, the number of people linked into the Internet 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. By 2004 the size of the e-commerce economy is estimated to be over \$6 trillion!

As a consequence, 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, our avatars, 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 will allow human interaction with essentially any degree of fidelity we wish—3-D, multimedia, telepresence, perhaps even directly linking our neural networks into cyberspace, a la *Neuromancer*⁸, a merging of carbon and silicon.

The Age of Knowledge

Looking back over history, one can identify certain periods of profound change in the nature, the fabric, of our civilization such as the Renaissance, the Age of Discovery, and the Industrial Revolution. There are many who contend that our society is once again undergoing such a fundamental shift in perspective and structure. The signs are all around us. We are evolving rapidly into a postindustrial, knowledge-based society, just as a century ago an agrarian America evolved into an industrial nation.⁹ Today industrial production is steadily shifting from material- and labor-intensive products and processes to knowledge-intensive products. A radically new system for

creating wealth has evolved that depends upon the creation and application of new knowledge. We are in a transition period where intellectual capital, brainpower, is replacing financial and physical capital as the key to our strength, prosperity, and well being. In a very real sense, we are entering a new age, an *age of knowledge*, in which the key strategic resource necessary for prosperity has become knowledge itself, that is, educated people and their ideas.¹⁰

Our rapid evolution into a knowledge-based society has been driven in part by the emergence of powerful new information technologies such as computers, digital communications networks, multimedia, and virtual reality. Modern electronic technologies have increased vastly our capacity to know and to do things and to communicate and collaborate with others. They allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways. We learn about events almost as they occur. The world has become linked electronically. This technology allows us to form and sustain communities for work, play, and learning in ways unimaginable just a decade ago.

Of course, our world has experienced other periods of dramatic change driven by technology, for example, the impact of the steam engine, telephone, automobile, and railroad in the late nineteenth century, which created our urban industrialized society.¹¹ But never before have we experienced a technology that has evolved so rapidly, increasing in power by a hundredfold or more every decade, obliterating the constraints of space and time, and reshaping the way we communicate, think, and learn.

Unlike natural resources such as iron and oil that have driven earlier economic transformations, knowledge is inexhaustible. The more it is used, the more it multiplies and expands. But knowledge is not available to all. It can be absorbed and applied only by the educated mind. Hence as our society becomes ever more knowledge-intensive, it becomes ever more dependent upon those social institutions that create knowledge, that educate people, and that provide them with knowledge and learning resources throughout their lives.¹² Schools in general and universities in particular will play increasingly important roles as our society enters this new age. The increasingly sophisticated labor market of a knowledge-driven economy is driving new needs for advanced education and training. Even today roughly two-thirds of America's high school graduates will pursue some form of college education, and this will likely increase as a college degree becomes the entry credential to the high-performance workplace in the years ahead. There is an increasingly strong correlation between the level of one's education and personal prosperity and quality of life.

The age of knowledge holds an even deeper significance for higher education. In a sense, knowledge is the medium of the university. Through the activities of discovery, shaping, achieving, transmitting, and applying knowledge, the university serves society in myriad ways: educating the young, preserving our cultural heritage, providing the basic research so essential to our security and well-being, training our professionals and certifying their competence, challenging our society and stimulating social change. Yet in a world in which knowledge and educated people have become the key to prosperity and security, there has been an increasing tendency for society to view the university as an engine for economic growth through the generation and application of new knowledge.

The university has survived other periods of technology-driven social change with its basic structure and activities intact. But the changes driven by evolving information technology are different, since they affect the very nature of the fundamental activities of the university: creating, preserving, integrating, transmitting, and applying knowledge. More fundamentally, because information technology changes the relationship between people and knowledge, it is likely to reshape in profound ways knowledge-based institutions such as the university.

The Impact of Information Technology on the Activities of the University

Over the past several decades, computers have evolved into powerful information systems with high-speed connectivity to other systems throughout the world. Public and private networks permit voice, image, and data to be made instantaneously available across the world to wide audiences at low costs. The creation of virtual environments where human senses are exposed to artificially created sights, sounds, and feelings liberate us from restrictions set by the physical forces of the world in which we live. Close, empathic, multi-party relationships mediated by visual and aural digital communications systems are becoming common. They lead to the formation of closely bonded, widely dispersed communities of people interested in sharing new experiences and intellectual pursuits created within the human mind via sensory stimuli. Computer-based learning systems are also being explored, opening the way to new modes of instruction and learning. New models of libraries are being explored to exploit the ability to access vast amounts of digital data in physically dispersed computer systems, which can be remotely accessed by users over information networks.

New forms of knowledge accumulation are evolving: written text, dynamic images, voices, and instructions on how to create new sensory environments can be packaged in dynamic modes of communication never before possible. The applications of such new knowledge forms challenge the creativity and intent of authors, teachers, and students. Technology such as computers, networks, high-definition television, ubiquitous computing, knowbots, and other technologies may well invalidate most of the current assumptions and thinking about the future nature of the university. It is of particular note that 40 percent of all new investment in capital facilities in our society today goes to purchase information technology. Needless to say, this need for investment in information technology applies to universities just as much as it does to the commercial or government sector. And it poses just as much of a challenge.

There are several characteristics of information technology that set it apart from earlier experiences with technology-driven change:

- Its active rather than passive nature;
- The way that it obliterates the constraints of space and time (and perhaps reality);
- Its extraordinary rate of evolution, relentlessly increasing in power
- by factors of 100 to 1000 fold decade after decade; and
- The manner in which it unleashes the power of the market place.

Although it has been slower in coming, we are beginning to see the impact of technology on university teaching. Today's "digital generation" of students, media savvy, are demand new forms of pedagogy. They approach learning as a "plug-and-play" experience; they are unaccustomed and unwilling to learn sequentially—to read the manual—and instead are inclined to plunge in and learn through participation and experimentation. Although this type of learning is far different from the sequential, pyramidal approach of the traditional college curriculum, it may be far more effective for this generation, particularly when provided through a media-rich environment. It challenges the faculty to design technology-rich experiences and environments based upon interactive, collaborative learning.

Sophisticated networks and software environments can be used to break the classroom loose from the constraints of space and time and make learning available to anyone, anyplace, at any time. The simplest approach uses multimedia technology via the Internet to enable distance learning. Yet many believe that effective computer-network-mediated learning will not be simply an Internet extension of correspondence

or broadcast courses. Since learning requires the presence of communities, the key impact of information technology may be the development of computer-mediated communications and communities that are released from the constraints of space and time. There is already sufficient experience with such asynchronous learning networks to conclude that, at least for many subjects, the learning process is just as effective as the classroom experience. There are presently for-profit entities¹³ competing directly with traditional colleges and universities in the higher education marketplace through virtual university structures.

The attractiveness of computer-mediated distance learning is obvious for adult learners whose work or family obligations prevent attendance at conventional campuses. But perhaps more surprising is the degree to which many on-campus students are now using computer-based distance learning to augment their traditional education. Broadband digital networks can be used to enhance the multimedia capacity of hundreds of classrooms across campus and link them with campus residence halls and libraries. Electronic mail, teleconferencing, and collaboration technology is transforming our institutions from hierarchical, static organizations to networks of more dynamic and egalitarian communities. The most significant advantage of computer-mediated distant learning is access. Perhaps we should substitute “distributed” for “distance” learning, since the powerful new tools provided by information technology have the capacity to enrich all of education, stimulating us to rethink education from the perspective of the learner. The rich resources and new forms of social interaction enabled by information technology create the possibility of the objective of “better than being there” for distributed learning environments.

Distance learning based on computer-network-mediated paradigms allows universities to push their campus boundaries outward to serve learners anywhere, anytime. Those institutions willing and capable of building such learning networks will see their learning communities expand by an order of magnitude. In this sense, the traditional paradigm of “just-in-case” degree-based education can be more easily replaced by the “just in time” and “just-for-you” customized learning paradigms, more appropriate for a knowledge-driven society in which work and learning fuse together.

In the near term, at least, traditional models of education will coexist with new learning paradigms, providing a broader spectrum of learning opportunities in the years ahead. The transitions from student to learner, from teacher to designer/coach/consultant, and from alumnus to lifelong member of a learning community seem likely. And with these transitions and new options will come both an

increasing ability and responsibility to select, design, and control the learning environment on the part of learners.

So, too, information technology is reshaping the nature of research. The earliest applications of information technology have been for solving mathematical problems in science and technology. Today, problems that used to require the computational capacity of rooms of supercomputers can be tackled with contemporary laptop computer. The rapid evolution of this technology is enabling scholars to address previously unsolvable problems, e.g., proving the four-color conjecture in mathematics, analyzing molecules that have yet to be synthesized, or simulating the birth of the universe. The use of information technology to simulate natural phenomena has created a third modality of research, on par with theory and experimentation

New types of organizations are appearing that are based on evolving information technology. An example is the "collaboratory" concept, an advanced, distributed infrastructure that uses multimedia information technology to relax the constraints on distance, time, and even reality. The process of creating new knowledge is evolving rapidly away from the solitary scholar to teams of scholars, often spread over a number of disciplines. This technology provides the tools to create, from desktop publishing to digital photography and video to creating objects atom-by-atom. There may even be a shift in knowledge production somewhat away from the analysis of what has been to the creation of what has never been—drawing more on the experience of the artist than upon analytical skills of the scholar.

The preservation of knowledge is one of the most rapidly changing functions of the university. The computer—or more precisely, the "digital convergence" of various media from print-to-graphics-to-sound-to-sensory experiences through virtual reality—will likely move beyond the printing press in its impact on knowledge. Throughout the centuries, the intellectual focal point of the university has been its library, its collection of written works preserving the knowledge of civilization. Today such knowledge exists in many forms—as text, graphics, sound, algorithms, and virtual reality simulations—and it exists almost literally in the ether, distributed in digital representations over worldwide networks, accessible by anyone, and certainly not the prerogative of the privileged few in academe.

The library is becoming less a collection house and more a center for knowledge navigation, a facilitator of information retrieval and dissemination.¹⁴ In a sense, the library and the book are merging. One of the most profound changes will involve the evolution of software agents, collecting, organizing, relating, and summarizing knowledge on behalf of their human masters. Our capacity to reproduce and distribute

digital information with perfect accuracy and with essentially zero cost has shaken the very foundations of copyright and patent law and threatens to redefine the nature of the ownership of intellectual property. The legal and economic management of university intellectual property is rapidly becoming one of the most critical and complex issues facing higher education.

The Form and Function of the University

Colleges and universities are organized along intellectual lines, into schools and colleges, departments and programs, that have evolved over the decades (some would say largely following the structure of 19th Century science and literature rather than 21st Century knowledge). Furthermore, the governance, leadership, and management of the contemporary university are structured as well to reflect this intellectual organization as well as academic values of the university such as academic freedom and institutional autonomy rather than the command-communication-control administrative pyramid characterizing most organizations in business and government. The “contract” between members of the faculty and the university also reflects the unusual character of academic values and roles, the practice of tenure being perhaps the most visible example.

Yet we have suggested that information technology is already having great impact on the university. It has modified its fundamental activities of education, scholarship, and service to society quite significantly. Technology has created new channels of communication throughout the university and with broader society through mechanisms such as electronic mail and website conferences that largely bypass traditional administrative arrangement and external relationships. Technology has also completely transformed the manner in which information concerning the university, its people, and its activities is gathered, stored, and utilized.

Just as the university is challenged in adapting to new forms of teaching and research stimulated by rapidly evolving information technology, so too its organization, governance, management, and its relationships to students, faculty, and staff will require serious re-evaluation and almost certain change. For example, the new tools of scholarship and scholarly communication are eroding conventional disciplinary boundaries and extending the intellectual span, interests, and activities of faculty far beyond traditional organizational units such as departments or schools. This is particularly the case with younger faculty members whose interests and activities frequently cannot be characterized by traditional disciplinary terms.

Beyond driving a restructuring of the intellectual disciplines, information technology is likely to force a significant disaggregation of the university on both the horizontal (e.g., academic disciplines) and vertical (e.g., student services) scale. Faculty activity and even loyalty is increasingly associated with intellectual communities that extend across multiple institutions, frequently on a global scale. New providers are emerging that can far better handle many traditional university services, ranging from student housing to facilities management to health care. Colleges and universities will increasingly face the question of whether they should continue their full complement of activities or “outsource” some functions to lower cost and frequently higher quality providers.

It has become increasingly important that university planning and decision making not only take account of technological developments and challenges, but draw upon the expertise of people with technological expertise. Yet all too often, university leaders, governing boards, and even faculties ignore the rapid evolution of this technology, treating it more as science fiction than as a serious institutional challenge. To a degree this is not surprising, since in the early stages, new technologies sometimes look decidedly inferior to long-standing practices. For example, few would regard the current generation of computer-mediated distance learning programs as providing the socialization function associated with undergraduate education in a residential campus environment. Yet there have been countless instances of technologies, from personal computers to the Internet, that were characterized by technology learning curves far steeper than conventional practices. Such “disruptive technologies” have demonstrated the capacity to destroy entire industries, as the explosion of e-commerce makes all too apparent.

So, too, colleges and universities will need to reconsider a broad array of policies that have become antiquated in the digital age. Clearly those policies governing intellectual property, whether created through research or instructional activities, require a total overhaul. Traditional patent, copyright, and technology transfer policies make little sense in a world in which the digital products of intellectual activity can be reproduced an infinite number of times with perfect accuracy and at zero cost.¹⁵

Furthermore, the relationship between the university and its faculty, staff, and students needs to be reconsidered. The university will face a major challenge in retaining instructional “mindshare” among their best known faculty. Although we have long since adapted to the reality of those faculty getting released time and very substantial freedom with regard to research activities, there will be new challenges as instructional content becomes a valuable commodity in a for-profit postsecondary

education marketplace. Do we need new policies that restrict the faculty's ability to contract with outside organizations for instructional learningware. Can these policies be enforced in the highly competitive marketplace for our best faculty? Is it possible that we will see an unbundling of students and faculty from the university, with students acting more as mobile consumers, able to procure educational services from a highly competitive marketplace, and faculty members acting more as free-lance consultants, selling their services and their knowledge to the highest bidder?

In a sense, just as information technology has brought us to an inflection point in the nature of education and scholarship, it could also force us to redefine the relationship between the university and its teachers and students. Beyond this, we will face an ever mounting challenge in helping our students and faculties to keep pace with the extraordinary pace of technology evolution. Many universities are simply unprepared for the new plug-and-play generation, already experienced in using computers and net-savvy, who will expect—indeed, demand—sophisticated computing environments at college. In the old days we would wait for a generation of professors to pass on before an academic unit could evolve. In today's high-paced world, when the doubling time for technology evolution has collapsed to a year or less, we simply must look for effective ways to reskill our faculties or risk rapid obsolescence.

In positioning itself for this future of technology-driven change, universities should recognize several facts of contemporary life. First, robust, high-speed networks are becoming not only available but also absolutely essential for knowledge-driven enterprises such as universities. Powerful computers and network appliances are available at reasonable prices to students, but these will require a supporting network infrastructure. There will continue to be diversity in the technology needs of faculty, with the most intensive needs likely to arise in parts of the university such as the arts and humanities where strong external support may not be available. All universities face major challenges in keeping pace with the profound evolution of information and its implication for their activities. Not the least of these challenges is financial, since as a rule of thumb most organizations have found that staying abreast of this technology requires an annual investment of roughly 10 percent of their operating budget. For a very large campus such as the University of Michigan, this can amount to hundreds of millions of dollars per year!

Historically, technology has been seen as a capital expenditure for universities or as an experimental tool to be made available to only a few. In the future, higher education should conceive of information technology both as an investment a strategic asset for universities, critical to their academic mission and their administrative services,

that must be provided on a robust basis to the entire faculty, staff, and student body. Colleges and universities must learn an important lesson from the business community: Investment in robust information technology represents the table stakes for survival in the age of knowledge. If you are not willing to invest in this technology, then you may as well accept being confined to a backwater in the knowledge economy, if you survive at all.

The Post-Secondary Education Enterprise

The “e-economy” is growing at an annual rate of 175%. It is estimated that by 2004, the e-economy will be \$7 trillion, roughly 20% of the global economy. Beyond providing the graduates and knowledge needed by this digital economy, the contemporary university must be able to function in an increasingly digital world, in the way that it manages its resources, relates to clients, customers, and providers, and conducts its affairs. Put another way, “e-commerce”, “e-business”, and the “e-economy” must become an integral part of the university’s future if it is to survive the digital age.

We generally think of higher education as public enterprise, shaped by public policy and actions to serve a civic purpose. Yet market forces also act on our colleges and universities. Society seeks services such as education and research. Academic institutions must compete for students, faculty, and resources. To be sure, the market is a strange one, heavily subsidized and shaped by public investment so that prices are always far less than true costs. Furthermore, if prices such as tuition are largely fictitious, even more so is much of the value of education services, based on myths and vague perceptions such as the importance of a college degree as a ticket to success or the prestige associated with certain institutions. Ironically, the public expects not only the range of choice that a market provides but also the subsidies that make the price of a public higher education less than the cost of its provision.

In the past, most colleges and universities served local or regional populations. While there was competition among institutions for students, faculty, and resources—at least in the United States—the extent to which institutions controlled the awarding of degrees, that is, credentialing, gave universities an effective monopoly over advanced education. However, today all of these market constraints are being challenged. The growth in the size and complexity of the postsecondary enterprise is creating an expanding array of students and educational providers. Information technology eliminates the barriers of space and time and new competitive forces such as virtual

universities and for-profit education providers enter the marketplace to challenge credentialing.¹⁶

The weakening influence of traditional regulations and the emergence of new competitive forces, driven by changing societal needs, economic realities, and technology, are likely to drive a massive restructuring of the higher education enterprise. From the experience with other restructured sectors of our economy such as health care, transportation, communications, and energy, we could expect to see a significant reorganization of higher education, complete with the mergers, acquisitions, new competitors, and new products and services that have characterized other economic transformations. More generally, we may well be seeing the early stages of the appearance of a *global knowledge and learning industry*, in which the activities of traditional academic institutions converge with other knowledge-intensive organizations such as telecommunications, entertainment, and information service companies.

Although traditional colleges and universities could play a role in such a technology-based, market-driven future, they could both be threatened and reshaped by shifting societal needs, rapidly evolving technology, and aggressive for-profit entities and commercial forces. Together these could drive the higher education enterprise toward the mediocrity that has characterized other mass media markets such as television and journalism.

A key factor in this restructuring has been the emergence of new aggressive for-profit educator providers that are able to access the private capital markets (over \$4 billion in the last year). Most of these new entrants such as the University of Phoenix and Jones International University 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. Using online education, they are able to offer cost reductions of 60% or more over conventional corporate training programs since they avoid travel and employee time off. They are investing heavily (over \$100 million in 2000) in developing sophisticated instructional content, pedagogy, and assessment measures, 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 is formidable indeed. We might think of traditional higher education as sunning itself on the beach in the warm glow of a prosperous economy, unaware that the gentle surf lulling them to sleep is the

precursor of a 100 foot tsunami of market forces beyond the horizon that could sweep over them before they can react or escape.

This perspective of a market-driven restructuring of higher education as a technology-intensive industry, while perhaps both alien and distasteful to the academy, is nevertheless an important framework for considering the future of the university. While the postsecondary education market may have complex cross-subsidies and numerous public misconceptions, it is nevertheless very real and demanding, with the capacity to reward those who can respond to rapid change and punish those who cannot. Universities will have to learn to cope with the competitive pressures of this marketplace while preserving the most important of their traditional values and character.

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.

A contrasting and far brighter future is provided by the concept of a *society of learning*, in which universal or ubiquitous educational opportunities are provided to meet the broad and growing learning needs of our society. Today educated people and the knowledge they produce and utilize have become the keys to the economic prosperity and well-being of our society. Furthermore, one's education, knowledge, and skills have become primary determinants of one's personal standard of living, the quality of one's life.¹⁷

We are realizing that, just as our society has historically accepted the responsibility for providing needed services such as military security, health care, and transportation infrastructure in the past, today education has become a driving social need and societal responsibility. Today it has become the responsibility of democratic societies to provide their citizens with the education and training they need, throughout their lives, whenever, wherever, and however they desire it, at high quality and at an affordable cost.

Of course, this has been one of the great themes of higher education in America. Each evolutionary wave of higher education has aimed at educating a broader segment of society, at creating new educational forms to do that—the public universities, the land-grant universities, the normal and technical colleges, the community colleges. But today information technology may well enable an even more rapid evolution of educational “life-forms” more capable of serving the needs of a knowledge-driven society.

So what would be the nature of a university of the twenty-first century capable of creating and sustaining a society of learning? It would be impractical and foolhardy to suggest one particular model. The great and ever-increasing diversity characterizing higher education in America makes it clear that there will be many forms, many types of institutions serving our society. But there are a number of themes that will almost certainly factor into at least some part of the higher education enterprise.

Just as other social institutions, our universities 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.

In a society of learning, people would be continually surrounded by, immersed in, and absorbed in learning experiences. Information technology has now provided us with a means to create learning environments throughout one's life. These environments are able not only to transcend the constraints of space and time, but using artificial intelligence and genetic algorithms they, like us, are capable as well of learning and evolving to serve our changing educational needs.

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. In a sense, computer networks might even be regarded as a force that will tend to "democratize" learning, since it will extend

educational opportunities to those currently underserved by traditional colleges and universities.

The Challenge of University Leadership in the Digital Age

Today's college and university leaders face myriad important questions and decisions concerning the impact of information technology on their institutions. For example, they need to understand the degree to which this technology will transform their basic activities of teaching, research, and service. What will be the impact of this technology on the basic activities of the university, upon teaching and research? Will the classroom disappear? Will the residential campus experience of undergraduate education be overwhelmed by virtual universities or "edutainment." And what about the role that traditional forms of pedagogy will play in an increasingly online world? How should the university integrate information technology into its educational programs at the undergraduate, graduate, and professional school level? Will information technology alter the priorities among various university activities, e.g., the balance of educational activities related to socializing high school graduates compared to the rapid growth in the need for advanced education by adults in the high performance workplace?

What kind of information technology infrastructure will the university need? How will it finance the acquisition and maintenance of this technology? To what degree should an institution outsource the development and management of IT systems? How should the university approach its operations and management to best take advantage of this technology? How can institutions better link planning and decision making with likely technological developments and challenges? How can one provide students, faculty, and staff with the necessary training, support, and equipment to keep pace with the rapid evolution of information technology? What is the role of universities with respect to the "digital divide", the stratification of our society with respect to access to technology?

How do colleges and universities address the rapidly evolving commercial marketplace for educational services and content, including, in particular, the for-profit and dot.com providers? What strategies and actions should colleges and universities consider? What kind of alliances are useful for colleges and universities in this rapidly changing environment? With other academic institutions? With business? On a regional, national, or global scale? Should colleges and universities join together to

create a “best practices” organization that provides assistance in analyzing needs and opportunities?

How can colleges and universities grapple with the forces of disaggregation and aggregation associated with a technology-driven restructuring of the higher education enterprise? Will universities be forced to merge into larger units as the corporate world has experienced, or will they find it necessary to outsource or spinoff existing activities. Will more (or perhaps most) universities find themselves competing in a global marketplace, and how will that square with publicly supported universities? Will new learning lifeforms or ecologies evolve based upon information technology that will threaten the very existence of the university?

The list of questions and issues seems not only highly complex but overwhelming to university leaders, not to mention the state and federal governments that support higher education in America. Yet, surveys suggest that despite the profound nature of this issues, information technology usually does not rank high among the list of priorities for university planning and decision making.¹⁸ Perhaps this is due to the limited experience most college and university leaders have with this emerging technology. It could also be a sign of indecisiveness and procrastination. Yet, as the pace of technological change continues to accelerate, indecision and inaction can be the most dangerous course of all.

A National Academy Project

Last year 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 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 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, funded from internal Academy funds and 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, is there for the federal government and other stakeholders to protect through policies, programs, and investments the valuable role and contributions of the university during this period of change.

To this end, a Steering Committee 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 for the projects 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 Net (e.g., wireless, photonics)
- Relaxing (or obliterating) conventional constraints of space, time, monopoly
- Democratizing character of IT (access to information, education, research)
- Changing ways we handle digital data/information/knowledge
- Growing importance of intellectual capital relative to physical or financial capital

In January 2001 a two-day workshop was conducted at the National Academies with invited participation of 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 will be broadcast on the Research Channel and video-streamed from its website later this 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:

- The extraordinary evolutionary pace of information technology will not only continue for the next several decades, but it could well accelerate on a superexponential slope. The event horizons are moving ever closer. Technological surprises are becoming more common. The future is becoming less certain.
- The impact of information technology on the university will likely be profound, rapid, and discontinuous—just as it has been and will continue to be on 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.
- 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.
- 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).
- 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.

- Although we feel confident that information technology will continue its rapid 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.
- 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.

This second phase will include: 1) the formation of an ongoing roundtable group consisting of leaders from higher education, industry, and government to monitor and assess the implications of evolving technology; 2) the conduct of campus-based discussions among faculty and administrators on a number of university campuses (similar to the “Stresses on the Academy” study jointly conducted by the National Academies and the National Science Foundation during the 1990s); 3) leadership development conferences drawing together key constituencies both from the campuses (e.g., university administrators, faculty leadership, trustees) and from the stakeholders of the research university (e.g., government agencies, foundations, scholarly societies); and 4) the launch of a series of more focused research projects and technology demonstration efforts designed to raise awareness and assist institutions in developing appropriate strategies. These activities will be supported through the development of web-based resources such as web portals and knowledge environments that are intended to be maintained and serve for the next several years as resources for the higher education community and its stakeholders.

The ultimate goal of the National Academies project: is to assist research universities and their various stakeholders in responding to the challenges and opportunities presented by digital technology in such a way that strengthen and enhance those roles so important to the future of our nation and our world.

The Future of the Research University in the Digital Age

As a primary source of basic research and the next generation of scholars and professionals, the research university will remain an institution of great value. In an age in which knowledge and educated people become a society's most valuable resources, the research university has become ever more important as an intellectual force in our society. Today the research faculties in these institutions have become both the leaders and the arbiters of science and scholarship for the world. This group not only leads in knowledge production and distribution, but they have become the gatekeepers and standard-bearers, leading a complex knowledge system that both drives and sustains world education and learning. Furthermore, as highly educated scholars and professionals are increasingly sought as leaders in a knowledge-driven world, these institutions should continue to play a critical role.

Yet the broader higher education enterprise is changing rapidly—driven by changing social needs, powerful market force, and rapidly evolving technology—to serve a changing world. While the unique roles, the prestige, and the prosperity of the research university may allow it to defend the status quo for a time, this, too, will pose certain dangers. Furthermore, the research university is no longer seen as the top level of academic pecking order but instead as just one player in a broader higher education enterprise, where the priority will be educational services for a knowledge-driven society rather than specialized scholarship. 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.

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.

It is within this context of recognizing the unique mission and value of the research university even as we seek to preserve its relevance to the rest of higher education that we should examine several possible strategies for the future:

Isolation. Some of the most elite institutions may adopt a strategy of relying on their prestige and their prosperity to isolate themselves from change, to continue to do just what they have done in the past, and to be comfortable with their roles as niche players in the higher education enterprise. And this may be a very appropriate strategy for some unique institutions, places such as MIT, Caltech, Princeton, and Chicago. But for most of the larger and comprehensive institutions, the activities of elite education and basic research are simply too expensive to sustain without some attention to the marketplace.

Pathfinders. 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.

Alliances. Extending this role somewhat, research universities might enter into alliances with other types of educational institutions, regional universities, liberal arts colleges, community colleges, or even newly emerging forms such as for-profit or cyberspace universities. This would allow them to respond to the changing needs of societies while remaining focused on their unique missions as research universities. One could also imagine forming alliances with organizations outside of higher education, for example, information technology, telecommunications, or entertainment companies, information services providers, or even government agencies.

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. 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 physical place, 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.

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.

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.”¹⁹ 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.²⁰

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.

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²⁰ James J. Duderstadt, *A University for the 21st Century* (University of Michigan Press, Ann Arbor, 2000).