The Future of the University in the Digital Age

James J. Duderstadt
University Professor of Science and Engineering
President Emeritus
The University of Michigan
Ann Arbor, Michigan 48109

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> 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.
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> —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 the research university.[2]

The university 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 have 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, although

Of course, there are always skeptics such as those who note that since it took several decades for the overhead transparency projector to make it from the bowling alley into the classroom, computers may bounce off of the classroom just as did technology-based media such as television. Yet there are many signs that this technology has already penetrated far into the fabric of our academic programs. For example, in recent surveys at the University of Michigan, we found that over 90 percent of our first-year students arrived on campus with at least three years of computer experience, and essentially all graduating seniors indicated they made extensive use of computers during their education. Over 60 percent owned computers when they first

arrived on campus, and almost 90 percent did so by the time of graduation. Our students currently spend about twelve to fourteen hours a week on a computer, with roughly half of this on the Net. Furthermore faculty members indicated that they spend about twenty hours a week working on computers with a significant fraction of this work done at home. Over 90 percent of faculty have personal computers in their office, at home, on the road, and some even in their pockets with personal digital appliances

Yet, while this technology has the capacity to enhance and enrich teaching and scholarship, it also poses certain threats to the university. 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 now to “I-campuses”, as MIT calls its Faustian bargain with Microsoft to develop jointly instructional technology. 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 Versity.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 both 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.

Some have even suggested 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. Several recent quotes illustrate the concerns:

> “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 for the printed book.” Peter Drucker, business sage

> "If you believe that an institution that has survived for a millennium cannot disappear in a just a few decades, just ask yourself what has happened to the family farm." William Wulf, President of the National Academy of Engineering

> "I wonder at times if we are not like the dinosaurs, looking up at the sky at the approaching asteroid and wondering whether it has an implication for our future." Frank Rhodes, President Emeritus, Cornell University

While most others believe the university will survive the digital age, few deny that it could change dramatically in form and character. Of course, our society has been through 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.[3] But never before have we experienced a technology that has evolved so rapidly, increasing in power by a hundredfold every decade, obliterating the constraints of space and time, and reshaping the way we communicate, think, and learn. 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 orders of magnitude every decade will have a profound impact on the both the mission and the function of the university.

So what challenges will the university face as we enter the digital age? Will this be just another period of evolution of 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 first provide–indeed, acknowledge–some background concerning my personal experience with this rapidly evolving technology.

A Personal Perspective

Let me begin with a personal caveat. Not only has my life essentially spanned that of the digital computer, but my particular area of study, nuclear energy, both stimulated and drove the development of this technology during much of its history.

- From mainframes to minicomputers to microcomputers
- From the IBM Stretch to CDC Star to the Cray to massively parallel supercomputers
- From Ethernet to Arpanet to NSFnet to Internet to Internet2
- From key-punched cards to teletype terminals to graphical displays to GUIs to virtual reality CAVEs
- From batch processing to time-sharing to personal computing to client-server to distributed processing
- From the TRS 80 and Apple II to the IBM PC and Lisa to Pentium III and G-4s
- From desktops to laptops to personal digital assistants to ubiquitous computing
- From Unix to MS-DOS to Mac OS to Windows NT to Linux

All of my activities, from research to teaching, from administration to communication, have been influenced by this technology from the earliest days of my career. After all, the objects of my study, whether they were nuclear fission reactors or inertially confined thermonuclear fusion reactions or nuclear rocket engines, were hardly the phenomenon for laboratory study. Instead elaborate computer models were constructed to simulate such systems, relying on sophisticated mathematics, physics, and engineering concepts. Even the fundamental physics was simulated at the microscopic level using Monte Carlo methods or molecular dynamics simulations.

But beyond the science itself, my life as a scholar, teacher, and administrator was reshaped by each new "killer app"…

- e-mail
- wordprocessors
- spreadsheets
- symbolic mathematical tools such as Mathematica or Maple
- idea processors
- presentation software
- web browsers
- data warehouses and data mining
- net-based telephony and video streaming

Looking back over my 30 years as a faculty member and academic administrator, it is hard to imagine how I could have functioned without these tools. Hence, you can regard my speculations about the future of the university as those of one whose career paralleled the evolution of this technology.

Even with this experience, 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.[4] This corresponds to a hundredfold increase in computing speed, storage capacity, and network transmission rates every decade. At such rates, by the year 2020, the thousand-dollar notebook computer will have a computing speed of 1 million gigahertz, a memory of thousands of terabits, 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.[5]

Yet 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. 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. Bell Laboratories suggests that within two decades a "global communications skin" will have evolved, linking together billions of computers that handle the routine tasks of our society, from driving our cars to watering our lawns to maintaining our health.

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[6], a merging of carbon and silicon.

The Impact of Information Technology on the Activities of the University

Let me first turn to some speculation concerning the impact of information technology on the fundamental processes of the university, our teaching and scholarship.

Teaching

Although it has been slower in coming, we are beginning to see the impact of technology on teaching. Interestingly enough, it does not seem to be driven by the faculty or our universities but rather by students themselves. Members of today's "digital generation" of students have spent their early lives surrounded by robust, visual, electronic media—Sesame Street, MTV, home computers, video games, cyberspace networks, MUDs and MOOS, and virtual reality. Unlike those of us who were raised in an era of passive, broadcast media such as radio and television, today's students expect—indeed, demand—interaction. 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 could well be that faculty members of the 21st Century university will find it necessary to set aside their roles as teachers and instead become designers of learning experiences, processes, and environments. Tomorrow's faculty members may have to rely less on the present style of solitary learning experiences, in which students tend to learn primarily on their own through reading, writing, and problem solving. Instead, students will demand that universities offer collective learning experiences, in which students work together and learn together, with the faculty member becoming more of a consultant or a coach than a teacher. Faculty members will be less concerned with identifying and then transmitting intellectual content and more focused on inspiring, motivating, and managing an active learning process by students. Of course this will

require a major change in graduate education, since few of today's faculty members have learned these skills.

Scholarship

The earliest applications of information technology in research involved using the computer for solving mathematical problems in science and technology, that is, for number crunching. My own field of research is characterized by complex mathematical models that used to exhaust the power of even the world's most powerful supercomputers. Yet 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.

Beyond solving complex mathematical models, we are increasingly able to simulate complex phenomena from first principles, e.g., solving the equations of motion for the billions of atoms comprising a material, analyzing the complex dynamics of the global climate, or simulating the crash of an automobile. 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 research organizations are appearing that are based on evolving information technology. An example is the "collaboratory",[7] an advanced, distributed infrastructure that uses multimedia information technology to relax the constraints on distance, time, and even reality. For example, Michigan joined with several universities in North America and Europe to operate a collaboratory for remote atmospheric measurements in Greenland. There is a vast array of human team activities in commerce, education, and the arts would be supported by variants of this concept. Perhaps some form of the collaboratory is the appropriate infrastructure ("tooling") for the "learning organization" becoming popular in the business world; perhaps it is the basis for the world universities in the next century. It could well become the generic infrastructure on which to build the workplace of the emerging information age.

There are other more subtle shifts in scholarship that can be related to emerging information technology. 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. Information technology leverages and enhances intellectual span. Is the concept of the disciplinary specialist really necessary—or even relevant—in a future in which the most interesting and significant problems will require "big think" rather than "small think"? What would be the value of a specialist in a future in which intelligent

software agents roam far and wide through robust networks containing the knowledge of the world, instantly and effortlessly extracting whatever a person needs to know.

This technology also provides the tools to create, from desktop publishing to digital photography and video to synthesizing objects atom-by-atom. We are developing the capacity to create new life-forms through the tools of molecular biology and genetic engineering. And, we are now creating new intellectual entities through artificial intelligence and virtual reality. 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 scientist.

The Library

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.[8] 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 at 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.[9] 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

Universities are supposed to be at the cutting edge of both knowledge generation and transmission. Yet their primary activity, teaching, is conducted today much as it was a century ago. Technologies that were supposed to drive radical change—television, computer-assisted instruction, wireless communications—have bounced off the classroom without a dent. To be sure, information technology has had great impact on the efficiency of administrative operations. It has revolutionized the conduct of research and the storage and synthesis of knowledge. But it has only had a marginal impact on instruction and learning, primarily being used only at the margins to extend the current classroom-centered paradigm.

However, today there are good reasons to believe that digital technology will indeed transform the university, perhaps beyond recognition. Why? What is different? Is it the ability of this new technology to cut the bonds of space and time? Is it its ubiquitous nature? No, it is the ability of the rapidly evolving digital technology to enable new forms of human interaction, to mediate communication, to stimulate the formation of new types of human communities. It will drive the focus of higher education from teaching to learning, and it will transform universities from faculty-centered to learner-centered institutions.

So what are possible paradigms for the "cyberspace university"? How can we create digitally mediated environments for learning?

Virtual Universities

Perhaps the most popular new approach is the so-called virtual university, most commonly conceived as the Internet extension of conventional distance learning. In cybertalk, "virtual" is an adjective that means existing in function but not in form. A virtual university exists only in cyberspace, without campus or perhaps even faculty. Sophisticated networks and software environments are used to break the classroom loose from the constraints of space and time and make learning available to anyone, anyplace, at any time.

For many years universities have utilized passive telecommunications technology such as television to extend teaching to people unable or unwilling to attend campus-based classes. In its simplest form, such distance learning is really a "talking heads" paradigm, in which faculty lectures are simply delivered at a distance, either through live transmission or videotape. There have been efforts to broadcast such instruction on public television ("sunrise semesters"), augmented by written correspondence. A more effective approach utilizes onsite teaching assistants to work directly with the students. Recently, technology has allowed the use of feedback via electronic mail, chatrooms, or two-way video interaction.

The simplest conception of the virtual university uses multimedia technology via the Internet to enable distance learning. Such instruction could be delivered either into the workplace or the home. In one form, this Internet-mediated instruction would be synchronous—in real time with the instructor and the students interacting together. The more interesting teaching paradigms of the virtual university involve asynchronous interactions, in which students and faculty interact at different times. In a sense, this latter form would resemble a correspondence course, with multimedia computers and networks replacing the mailing of written materials. There is already sufficient experience with such asynchronous learning to conclude that, at least for many subjects, the learning process is just as effective as the classroom experience. Furthermore, because one need not invest in the physical infrastructure of the campus, there is opportunity for significant cost reductions in the long term. By using an inexpensive delivery mechanism such as the Internet to reach a potentially vast audience, many hope that a virtual university can provide instruction at costs far lower than campus-based instruction. There are presently for-profit entities[10] competing directly with traditional colleges and universities in the higher education marketplace through virtual university structures.

The attractiveness of virtual universities is obvious for adult learners whose work or family obligations prevent attendance at conventional campuses.[11] But perhaps more surprising is the degree to which many on-campus students are now using virtual university communities 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.

Distance-Independent Learning Communities

Many believe that effective computer-network-mediated learning will not be simply an Internet extension of correspondence or broadcast courses. John Seeley Brown and Paul Duguid of Xerox PARC believe that this model of the virtual university overlooks the nature of how university-based learning actually occurs.[12] They suggest that it is a mistake to think of learning as information transfer, the act of delivering knowledge to passive student receivers. Brown and Duguid see the learning process as rooted both in experience and social interaction. Learning requires the presence of communities. This is, of course, the reason why the residential campus provides such a powerful learning environment and, at least for the near term, is unlikely to disappear.

Once we have realized that the core competency of the university is not simply transferring knowledge, but developing it within intricate and robust networks and communities, we realize that the simple distance-learning paradigm of the virtual university is inadequate. The key is to develop computer-mediated communications and communities that are released from the constraints of space and time.

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" education packages in degree programs early in one's life can be more easily replaced by the "just in time" learning paradigms, more appropriate for a knowledge-driven society in which work and learning fuse together, and "just-for-you" learning opportunities, customized to one's learning needs and styles.

Competition from Cyberspace

Of course, the use of information technology is already quite pervasive in higher education. Courses are increasingly being offered, both on campus and off, via the Internet. Students in geographically dispersed virtual communities meet together electronically. It is also clear that in most cases information technology is underutilized, serving as extensions rather than transformations of the way we learn and teach.[13]

To be sure, the current concept of distance learning, even if implemented via the Internet through virtual universities, is still bound to traditional ideas and approaches.[14] But as true learning communities are constructed in cyberspace, traditional educational institutions will feel increasing competition and pressure to change. The university will continue to be the primary source of "content" for educational programs, but other organizations more experienced in "packaging" content, for example, entertainment companies, may compete with universities to provide educational services to the mass market. In a similar sense, it could well be that the role of the faculty member will shift rapidly from that of organizing and teaching individual courses. As higher education shifts from a cottage industry to mass production, faculty may become members of design teams developing content for broader markets.

These changes could well force a structural reorganization of the university, perhaps breaking it up into its component functions such as credentialling, guidance, research, and instruction. The traditional lecture system, intrinsically inefficient in knowledge transmission, could decline in importance as robust electronically mediated technology becomes available. This technology may enable an expansion of other

activities requiring direct human contact, such as guidance, tutorials, and hands-on mentoring.

It is ironic that the cyberspace paradigm of learning communities is a mechanism that may return higher learning to the older tradition of the scholar surrounded by disciples in an intense interrelationship. In a sense, it recognizes that the true advantages of universities are in the educational process, in the array of social interactions, counseling, tutorial, and hands-on mentoring activities that require human interaction. In this sense, information technology will not so much transform higher education—at least in the early phases—as enrich the educational opportunities available to learners.

Liberal arts colleges that continue to stress such mentoring, hands-on, tutorial-based education will be least challenged by the emerging knowledge media. It is the large, comprehensive universities that rely heavily on impersonal mass education that are at great risk. A significant share of this conventional mass education can be offered commercially and electronically. After all, a large part of the function of large universities is mass information transfer, which can be performed quite effectively and efficiently via information technology. Virtual universities, even when constructed along the conventional distance-learning paradigm, may well provide formidable competition to large universities in terms of both quality and price.

Perhaps we should pay more attention to developing new learning structures more appropriate for the evolving information technology. One example noted earlier is the collaboratory,[15] an advanced, distributed infrastructure that would use multimedia information technology to relax the constraints on distance, time, and even reality. There is an important implication here. Information technology may allow—perhaps even require—new paradigms for learning organizations that go beyond traditional structures such as research universities, federal research laboratories, research projects, centers, and institutes. If this is the case, we should place a far higher priority on moving to link together our students and educators among themselves and with the rest of the world. This would be a modest investment compared with the massive investments we have made in the institutions of the past—university campuses, transportation, and urban infrastructure. It is none too early to consider an overarching agenda to develop deeper understanding of the interplay between advanced information technology and social systems. In some future time we may have the knowledge to synthesize both in an integrated way as a total system.

The Post-Secondary Education Enterprise

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, credentialling, 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 credentialling.

A Market-Driven Restucturing of Higher Education

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 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.

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 Society of Learning

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.

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.

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.

- *Learner-centered:* 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.

- *Affordable:* Society will 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.

- *Lifelong Learning:* 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.

- *Interactive and Collaborative:* 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.

- *Diverse:* The great diversity characterizing higher education in America will continue, as it must to serve an increasingly diverse population with diverse needs and goals.

- *Intelligent and adaptive*: Knowledge and distributed intelligence technology will increasingly allow us to build learning environments that are not only highly customized but adapt to the needs of the learner

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 they, like us, are capable as well of learning and evolving to serve our changing educational needs.

Concluding Remarks

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?

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. In this sense, 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. Furthermore, the new knowledge media enables us to build and sustain new types of learning communities, free from the constraints of space and time. 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.

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."[16] 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.

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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[1] Jacques Attali, *Millennium: Winners and Losers in the Coming World Order* (New York: Times Books, 1992), 11.

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

[3] Steve Lohr, "The Future Came Faster in the Old Days," *New York Times* (October 5, 1998).

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

[5] Ray Kurzweil, *The Age of Spirtual Machines: When Computers Exceed Human Intelligence* (New York: Viking, 1999).

[6] William Gibson, *Neuromancer* (New York: Ace, 1984).
[7] "All the World's a Lab," *New Scientist* 2077 April 12, 1997, 24-27; T. A. Finholt and G. M. Olson, "From Laboratories to Collaboratories: A New Social Organizational Form for Scientific Collaboration," *Psychological Science* 9, 1 (1997), 28-36.
[8] "Books, Bricks, and Bytes," *Daedelus* 125, no. 4, (1996), v-vii.
[9] John Perry Barlow, "The Economy of Ideas: A Framework for Rethinking Patents and Copyrights in the Digital Age," *Wired*, 2.03 (March 1994).
[10] Ted Marchese, "Not-So-Distant Competitors: How New Providers Are Remaking the Postsecondary Marketplace," *AAHE Bulletin* May 1998, <http://www.aahe.org/bulletin/bull_1/May 98 html>.
[11] For an excellent example of such virtual universities, see the website for the Michigan Virtual Automotive College at <http://www.mvac.org> and the article by Scott Bernato, "Big 3 U," *University Busines*s, September–October 1998, 20–27.
[12] John Seely Brown and Paul Duguid, *Universities in the Digital Age*, *Change*, July, 1996, pp. 11-19.
[13] Richard N. Katz, ed., *Dancing with the Devil: Information Technology and the New Competition in Higher Education* (San Francisco: Educause and Jossey-Bass, 1998).
[14] Myles Brand, "The Wise Use of Technology," *Educational Record* Fall 1995, 39–46.
[15] "All the World's a Lab," *New Scientist* 2077 April 12, 1997, 24-27; T. A. Finholt and G. M. Olson, "From Laboratories to Collaboratories: A New Social Organizational Form for Scientific Collaboration," *Psychological Science* 9, 1 (1997), 28-36.
[16] William J. Mitchell, *City of Bits: Space, Place, and the Infobahn* (Cambridge: MIT Press, 1995), <http://www-mitpress.mit.edu/City_of_Bits>.