The Future of the University
in an Age of Knowledge

James J. Duderstadt

President Emeritus and
University Professor of Science and Engineering

After fifteen years as an academic administrator, I was taken aback by a flyer posted near my faculty office that advertised the following curriculum:

> "Students will begin by learning the C++ programming language and corresponding operating system on their choice of platforms, including Unix, Macintosh, and Windows-NT on state-of-the art systems including Pentium, Macintosh, Sun, and HP workstations and Convex Exemplar and IBM SP-2 supercomputers. In addition they will learn HTML, Javascript, and create a home page on the World Wide Web. They will explore computer graphics and animation, including still imagery and video with Macromedia Director and Photoshop. They will use these tools to explore the technological fields of robotics and artificial intelligence."[i]

This sounded like a rather advanced for college students, even at the graduate level. By then, as I read the fine print, I noticed that this poster was not aimed at college students. Instead it was advertising a summer camp run by our engineering college for high school students of ages 13 to 17!

Needless to say, this provided yet another data point that information technology was not only challenging and changing our institutions, but it was also changing substantially the knowledge base of the students entering our universities.

A Time of Challenge and Change

We are living in the most extraordinary of times: the end of the Cold War, a redefinition of the world economic order, the impact of technologies ranging from computers and telecommunication to biotechnology, and, of course, a time in which the human population is pushing against the very limits of the planet. Many believe that we are going through a period of change in our civilization just as momentous as that which occurred in earlier times such as the Renaissance or the Industrial Revolution—except that while these earlier transformations took centuries to occur, the transformations characterizing our times will occur in a decade or less!

This time of great change, of shifting paradigms, provides the context in which we must consider the changing nature of the higher education enterprise itself. We must take great care not simply to extrapolate the past but instead to examine the full range of possibilities of the future.

From this broader perspective, we find that four important themes are converging in the final decade of the 20th Century: i) the importance of knowledge as a key factor in determining security, prosperity, and quality of life; ii) the global nature of our society; iii) the ease with which information technology—computers, telecommunications, and multimedia—enables the rapid exchange of information; and iv) networking, the degree to which informal cooperation and collaboration among individuals and institutions are replacing

more formal social structures, such as corporations, universities, and governments.

We have entered an *age of knowledge* in which educated people and their ideas have become strategic commodities essential to our security, prosperity, and social well-being. But unlike other resources such as mineral ores, timber, and access to low-skilled labor, knowledge knows no boundaries. It is generated and shared wherever educated and creative people come together. It cannot be exhausted; the more it is used, the more it multiplies.

The Challenges to the University

Rapidly evolving information technologies are dramatically changing the way we collect, manipulate, and transmit knowledge. They have increased vastly our capacity to know and to do things. They allow us to exchange information, to communicate, and to collaborate free from the constraints of space and time. Needless to say, the implications of this technology for knowledge-intensive organizations such as universities are profound indeed.

One frequently hears the primary missions of the university characterized as teaching, research, and service. But, these activities can also be regarded as simply the 20th Century manifestations of the more fundamental roles of *creating, preserving, integrating, transmitting,* and *applying* knowledge. If we were to adopt the more contemporary language of information technology, the university might be regarded as a "knowledge server," providing knowledge services (i.e., creating, preserving, transmitting, or applying knowledge) in whatever form needed by contemporary society.

From this more abstract viewpoint, it is clear that, while the fundamental knowledge server roles of the university do not change over time, the particular realization of these roles does change–and changes quite dramatically, in fact. Consider, for example, the role of "teaching," that is, transmitting knowledge. We generally think of this role in terms of a professor teaching a class of students, who respond by reading assigned texts, writing papers, solving problems or performing experiments, and taking examinations. We should also recognize that classroom instruction is a relatively recent form of pedagogy. Throughout the last millennium, the more common form of learning was through apprenticeship. Both the neophyte scholar and the craftsman learned by working as apprentices to a master. While this type of one-on-one learning still occurs today in skilled professions such as medicine and in advanced education programs such as the Ph.D. dissertation, it is simply too labor-intensive for the mass educational needs of modern society.

The classroom itself may soon be replaced by more appropriate and efficient learning experiences. Indeed, such a paradigm shift may be forced upon the faculty by the students themselves. Today's students are members of the "digital generation."   They have spent their early lives surrounded by robust, visual, electronic media—Sesame Street, MTV, home computers, video games,

cyberspace networks, MUDs, MOOs, and virtual reality. They approach learning as a "plug-and-play" experience. They are unaccustomed and unwilling to learn sequentially—to read the manual—and are inclined to plunge in and learn through participation and experimentation. While this type of learning is far different from the sequential, pyramid approach of the traditional university 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. Further, tomorrow's faculty may have to discard the present style of solitary learning experiences in which students tend to learn primarily on their own through reading, writing, and problem solving. Instead, they may be asked to develop 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.

One can easily identify other similarly profound changes occurring in the other roles of the university. The process of creating new knowledge—of research and scholarship—is also evolving rapidly away from the solitary scholar to teams of scholars, perhaps spread over a number of disciplines. One might well question whether the concept of the disciplinary specialist is relevant to a future in which the most interesting and significant problems will require "big think" rather than "small think." Who needs specialists in an age where intelligent software agents may soon be available to roam far and wide through robust networks containing the knowledge of the world, instantly and effortlessly extracting whatever a person wishes to know?

So too there is increasing pressure to draw research topics more directly from worldly experience and needs rather than predominantly from the curiosity of scholars. Even the nature of knowledge creation is shifting somewhat away from the analysis of what has been to the creation of what has never been—drawing as much on the experience of the artist as the analytical skills of the scientist.

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 emerging virtual reality—will 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 role of the library is becoming less that of collecting and more that of a knowledge navigator, a facilitator of retrieval and dissemination.

Finally, it is also clear that societal needs will continue to dictate great changes in the applications of knowledge it expects from universities. Over the past several decades, universities have been asked to play key roles in applying knowledge across a wide array of activities, from providing health care to protecting the environment, from rebuilding our cities to entertaining the public at large (although it is sometimes hard to understand how intercollegiate athletics represents knowledge application). It is difficult to imagine the roles society will ask the university to play in the century ahead; we can only be certain they will be different from the roles we play today.

Changes in the Higher Education Enterprise

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, credentialing, led to tightly controlled competitive markets.

Today, universities are facing new competitive forces. As the need for advanced education becomes more intense, some institutions are moving far beyond their traditional geographical areas to compete for students and resources. There are hundreds of colleges and universities that increasingly view themselves as competing in a national or even international marketplace. Even within regions such as local communities, colleges and universities that used to enjoy a geographical monopoly now find that other institutions are establishing beachheads through extension services, distance learning, or even branch campuses. Furthermore, with advances in communications, transportation, and global commerce, several universities in the United States and abroad are increasingly viewing themselves as international institutions, competing in a global marketplace.

In a very real sense, higher education is evolving from a loosely federated system of colleges and universities serving traditional students from local communities into a rapidly expanding knowledge industry. Since nations throughout the world recognize the importance of advanced education, this industry is global in extent. With the emergence of new competitive forces and the weakening influence of traditional regulations, it is evolving like other deregulated industries, e.g., communications or energy. It is strongly driven by changing technology. And as our society becomes ever more dependent upon new knowledge and educated people, upon knowledge workers, the knowledge business must be viewed clearly as one of the most active growth industries of our times.

Many in the academy would undoubtedly view with derision or alarm the depiction of the higher education enterprise as an "industry," operating in a highly competitive, increasingly deregulated global marketplace. However this is nevertheless an important perspective that will require a new paradigm for how we think about post-secondary education.

Unbundling

The modern university has evolved into a monolithic institution controlling all aspects of learning. In a sense, the faculty has long been accustomed to dictating what it wishes to teach, how it will teach it, and where and when the learning will occur. Students must travel to the campus to learn. They must work their way through the bureaucracy of university admissions, counseling, scheduling, and residential living. If they complete the gauntlet of requirements, they are finally awarded a certificate to recognize their learning—a college degree.

Today, comprehensive universities—at least as full-service organizations—are at considerable risk. These institutions have become highly vertically integrated. They provide courses at the undergraduate, graduate, and professional level; support residential colleges; professional schools; lifelong learning; athletics; libraries; museums; athletics; entertainment; and on, and on, and on . . . . Yet today we are already beginning to see the growth of differentiated competitors for many of these activities. Universities are under increasing pressure to spin off or sell off or close down parts of their traditional operations in the face of this new competition.

The most significant impact of a deregulated higher education "industry" will be to break apart this monolith, much as other industries have been broken apart through deregulation. As universities are forced to evolve from "faculty-centered" to "learner-centered," they may well find it necessary to unbundle their many functions, ranging from admissions and counseling to instruction to certification.

From a Cottage Industry to Mass Production

Higher education is one of the few activities which has yet to evolve from the handicraft, one-of-a-kind cottage industry mode to the mass production enterprise of the industrial age. In a very real sense, the industrial age has largely passed the university by. Faculty continue to organize and teach their courses much as they have for decades—if not centuries. Faculty members design from scratch the courses they teach, whether they be for a dozen or several hundred students. They may use standard textbooks from time to time— although most do not—but their organization, their lectures, their assignments, their exams are developed for the particular course at the time it is taught. So too our social institutions for learning—schools, colleges, and universities—continue to favor programs and practices based more on past traditions than upon contemporary needs.

Universities—more correctly, their faculties—are skilled at creating the content for educational programs. Indeed, we might identify this as their core competency. But they have not traditionally been particularly adept at "packaging" this content for mass audiences. To be sure, many faculty have written best-selling textbooks, but these have been produced and distributed by textbook publishers. In the future of multimedia—Net-distributed educational

services—perhaps the university will have to outsource both production and distribution from those most experienced in reaching mass audiences—the entertainment industry.

Restructuring

The perception of the higher education enterprise as a deregulated industry has several other implications. There are over 3,600 colleges and universities in the United States, characterized by a great diversity in size, mission, constituencies, and funding sources. Not only are we likely to see the appearance of new educational entities in the years ahead, but as in other deregulated industries, there could well be a period of fundamental restructuring of the enterprise itself. Some colleges and universities might disappear. Others could merge. Some might actually acquire other institutions.

A case in point: The Big Ten universities (actually there are twelve, including the University of Chicago and Penn State University) are already merging many of their activities, such as their libraries and their federal relations activities. They are exploring ways to allow students at one institution to take courses—or even degree programs—from another institution in the alliance in a transparent and convenient way. They are even working together to position themselves to provide educational services on a global scale.

One might also imagine affiliations between comprehensive research universities and liberal arts colleges. This might allow the students enrolling at large research universities to enjoy the intense, highly personal experience of a liberal arts education at a small college while allowing the faculty members at these colleges to participate in the type of research activities only occurring on a large research campus.

Indeed, one might even imagine hostile takeovers, in which a Darwinian process emerges resulting in some institutions devouring their competitors. Such events have occurred in deregulated industries in the past, and all are possible in the future faced by higher education.

Some Operational Issues for Universities

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 roughly comparable to ten 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 each year.

It seems useful to set out some possible guidelines for such investments, learned from many years of experience at Michigan and other universities:

<u>Invest in "Big Pipes"</u>

While the processing power of computers continues to increase, of far more importance to universities is the increasing bandwidth of communications technology. Clearly both Internet access to off-campus resources and intranet capability to link students, faculty, and staff together are the highest priority. The key theme will be connectivity, essential to the formation and support of digitally mediated communities.

Universities are straining to keep up with the connectivity demands of students. Today's undergraduates are already spending hours every day interacting with faculty, students, and home while accessing knowledge distributed about the world. Simply keeping pace with an adequate number of modem ports to meet the demands of off-campus students for access to campus-based resources and the Internet is overloading many universities. Installing and maintaining a modern on-campus network—a "wire plant"—has become one of the most critical challenges facing most universities .

<u>Strive for a Multi-Vendor, Open Systems Environments</u>

Universities should avoid hitching their wagons to only one or two vendors. As information technology becomes more of a commodity marketplace, new companies and equipment will continue to spring forth. Furthermore, the great diversity in needs of various parts of the university community will require a highly diverse technology infrastructure. Humanists will seek robust network access to digital libraries and graphics processing. Scientists and engineers will seek massively parallel processing. Social scientists will likely seek the capacity to manage huge databases, e.g., data warehouses and data-mining technology. Artists, architects, and musicians will require multimedia technology. Business and financial operations will seek fast data processing, robust communications, and exceptionally high security.

It will be an ongoing challenge to link together these complex multi-vendor environments, characterized not only by different equipment being used for diverse purposes, but also diverse software and operating systems. For this reason, it is important to insist on open-systems technology rather than relying on proprietary systems. Fortunately, most information technology is moving rapidly away from proprietary mainframes ("big iron") to client-server systems based on standard operating systems such as Unix or Windows-NT. There is a vast array of commercial off-the-shelf software available for such open systems. Furthermore, the emergence of open document formats as part of the Net has raised the compatibility level from the vendor nameplate to the browser level.

Furthermore, as digital technology becomes increasingly ubiquitous, universities will face the challenge as to just what components they will provide and which should be the personal responsibility of members of the community. For example, while networks and specialized computing resources will continue to be the responsibility of the university, other digital devices such as personal

communicators will almost certainly be left to individual students, faculty, or staff members.

Student Participation

There continues to be an ongoing debate about whether students should be required to purchase their own computers. In reality, the majority of students entering college these days already have computers. Universities should be prepared to support the personal computing efforts of students by providing robust network linkages both in residence halls and student commons areas. Furthermore, they should negotiate with community telecommunications companies—both telephone and cable television companies—to provide sufficient network communication ports to facilitate off-campus students.

Perhaps more controversial is the role that universities can play in negotiating deep discounts with hardware manufacturers for student personal computers. Local retailers will sometimes complain that this represents unfair competition (although, in reality, most will benefit significantly from subsequent software and peripheral sales). However one can make a strong case that universities have an obligation to assist students in acquiring the hardware and software increasingly essential for their education.

Even as personal computer technology saturates the student body, universities should continue to build and maintain public computer sites where students can have access to more powerful technology. In a very real sense, these computer cluster sites are becoming analogous to the role that libraries played in the past. They provide students not only with the technology necessary for their studies, but also serve as places to study, gather, and collaborate.

Cultural Issues

One of the important strategic issues facing most universities will be the degree to which the evolution of information technology should be carefully coordinated and centralized or instead allowed to flourish in a relatively unconstrained manner in various units. Perhaps because of our size and highly decentralized culture, at Michigan we have long preferred the "let every flower bloom" approach. More to the point, we have encouraged islands of innovation, in which certain units are strongly encouraged to move out ahead, exploring new technologies, perhaps moving into leadership roles and serving as pathfinders for the rest of the university.

Yet another cultural issue involves just who within the university community will drive change. Our experience has been that it will not be the faculty or staff but rather the students. As members of the "digital generation," they are far more comfortable with this emerging technology. Furthermore, they represent a fault-tolerant population, willing to tolerate the inevitable bugs in "Version 1.0" of new hardware and software.

As one example of this phenomenon, it is clear that many students are already moving rapidly to embrace Net-based learning and are taking increasing control of their own education. Although enrolled in traditional academic programs and participating in time-tested pedagogy such as lecture courses, homework assignments, and laboratory experiments, when unleashed many students approach learning in very different ways when they work on their own. They use the Net to become "open learners," accessing world-wide resources and Net-based communities of utility to their learning objectives.

The Need for Experimentation

No one knows what this profound alteration in the fabric of our world will mean, both for the university and for our entire society. As William Mitchell, Dean of Architecture at MIT, stresses in his provocative Web-book, *City of Bits*,[ii] "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." 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.

Some examples currently underway at the University of Michigan illustrate both the nature and scale of such experiments:

The Media Union[iii]

At the University of Michigan we have just opened a new facility known as the Media Union, designed to be just such a laboratory, a test bed, for developing, studying, and implementing the new paradigms of the University enabled by information technology. It will give us the chance to try out different possibilities before they become widespread realities, helping us avoid potentially expensive or even dangerous mistakes while maximizing the extraordinary capacities of our new tools.

More specifically, this 250,000-square-foot facility contains almost 1,000 workstations for student use. It houses a 1,000,000 volume library, but perhaps more significantly, it is the site of several of our major digital library projects. It also contains a sophisticated teleconferencing facility, design studios, visualization laboratories, and a major virtual reality complex. Since art, architecture, and music students work side-by-side with engineering students, the Media Union contains sophisticated recording studios and electronic music studios. It also has a state-of-the-art sound stage for "digitizing" performances, as well as numerous galleries for displaying the results of student creative efforts. To respond to intense student interest and activity, the Media Union is open twenty-four hours a day, seven days a week, throughout the year.

The School of Information[iv]

Several years ago, at the University of Michigan, we became so convinced of the potential impact of information technology for the future of our institution that we decided to launch an internal R&D operation to explore and develop various possible paradigms for a 21st Century university. Rather than building an independent research center, instead we decided to take our smallest academic unit, the former School of Library Science and put at its helm one of our most creative scientists, Dan Atkins, with the challenge of developing new academic programs in "knowledge management." The result has been the rapid evolution—indeed, revolution—of this unit into a new School of Information.

Put simply, this school is committed to developing leaders for the information professions who will define, create, and operate facilities and services that will enable users, both as individuals and as members of teams, to create, access, and use information they need. It is leading the way in transforming education for the information professions through an innovative curriculum, drawing upon the strengths of librarianship, information and computer science, business, social sciences, organizational development, communication, and systems engineering. Its activities range from digital libraries to knowledge networks to virtual educational structures.

The Millennium Project[v]

Located in the Media Union is the Millennium Project, a research center bringing together leaders, faculty, and students to develop new paradigms for the University of the 21st Century. The Millennium Project is designed to go beyond theorizing to provide an experimental laboratory for the testing of innovations in teaching, research, outreach, and administration. In a sense, we hope the Millennium Project functions much as the famous Lockheed Skunkworks, that every so often its hanger doors will open and something strange and exciting will be wheeled out and flown away. One of our early projects is the Michigan Virtual Automobile College.

The Michigan Virtual Automobile College[vi]

In 1996 we participated in the creation of a new institution, the Michigan Virtual Auto College (MVAC), designed to explore the implications of digital technology for higher education. This is a collaborative effort among the University of Michigan, Michigan State University, the State of Michigan, the state's other colleges and universities, and the automobile industry. It was formed as a private, not-for-profit, 501(c)3 corporation aimed at developing and delivering technology-enhanced courses and training programs for the automobile industry, including both manufacturing and supplier companies. The MVAC serves as an interface between higher education institutions, training providers, and the automotive industry. It works to facilitate the transfer of credits between and among institutions to facilitate certificate and degree attainment for those participating in courses and training programs offered under its auspices. It is designed as a "green field" experiment where colleges and universities can come

together to test capabilities to deliver their training and educational programs at a distance and asynchronously. It is hoped that MVAC will eventually serve as a platform for the State of Michigan to build an education export industry.

The Ubiquitous University

Clearly, rapid evolution of information technology 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 classroom-based pedagogy. Yet, as the constraints of time and space—and perhaps even reality itself—are relaxed by information technology, one might question the degree to which these contemporary models of the university will continue to be relevant.

Although the many challenges facing higher education in the digital age suggest strongly that the university will change--indeed, that it must change--in very fundamental ways, they do not suggest a particular form for future universities. Rather 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 our discussions do suggest a number of themes that will likely characterize the higher education enterprise in the years ahead:

- *Lifelong Learning,* requiring both a willingness to continue to learn on the part of our citizens and a commitment to provide opportunities for this lifelong learning by our institutions
- *A Seamless Web*, in which all levels of education not only become interrelated, but blend together
- *Asynchronous* (anytime, anyplace) *Learning*, breaking the constraints of time and space to make learning opportunities more compatible with lifestyles and needs
- *Affordable*, within the resources of all citizens, whether through low cost or societal subsidy
- *Interactive and Collaborative*, appropriate for the digital age, the "plug and play" generation
- *Diversity*, sufficient to serve an increasingly diverse population with diverse needs and goals

Yet there is an even broader theme: In the age of knowledge, it has become increasingly clear that not only has knowledge become the wealth of nations, it has also become the key to one's personal standard of living, the quality of one's life. Hence, we might well make the case that 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 a cost they can afford.

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—the public universities, the land-grant universities, the normal and technical colleges, the community colleges.

For the past half a century, national security was America's most compelling priority, driving major public investments in social institutions such as the research university. Today, however, in the wake of the Cold War and on the brink of the age of knowledge, one could well make the argument that education will replace national defense as the priority of the 21st Century. Perhaps this will become the new social contract that will determine the character of our educational institutions, just as the government-university research partnership did in the latter half of the 20th Century. We might even conjecture that a social contract, based on developing the abilities and talents of our people to their fullest extent could well transform our schools, colleges, and universities into new forms that would rival the research university in importance.

Once again we need a new paradigm for delivering it to even broader segments of our society. Just as with other resources such as food, energy, and transportation that soon became necessities of modern life and therefore the responsibility of a society, today higher education itself has become a similar need.

Fortunately, today's technology is rapidly breaking the constraints of space and time. It has become clear that most people can learn and learn well using distant-independent learning technology. The barriers are no longer cost or technology but rather perception and habit. But perhaps even an enterprise dominated by *asynchronous* learning—*anytime, anyplace, for anyone*—may be only a transitional stage to a more radical future for higher education. Perhaps a more appropriate future for higher education—indeed, all of education—is that of a ubiquitous, *pervasive* learning environment—*everytime, everyplace, for everybody*. Indeed, in a world driven by an ever-expanding knowledge base, continuous learning like continuous improvement has become a necessity of life.

Rather than "an age of knowledge," perhaps we should aspire instead to building a "culture of learning," in which people are continually surrounded by, immersed in, and absorbed in learning experiences. Actually, this is not far from the environment experienced by a very young child, in which every stimulus becomes a learning opportunity. 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.

Perhaps the creation of these pervasive, ubiquitous cultures of learning is both the greatest challenge and the true future of the university.

---

[i] See the University of Michigan Computer Aided Engineering Network,
    http://www.engin.umich.edu/caen/
[ii] William Mitchell, City of Bits (M.I.T. Press, Cambridge, 1995)

http:// www-mitpress.mit.edu/City_of_Bits/

[iii] The University of Michigan Media Union,
        http://www.ummu.umich.edu/

[iv] The University of Michigan School of Information
        http://www.si.umich.edu/

[v] The Millennium Project
        http://www.umich.edu/~milproj/

[vi] The Michigan Virtual Automobile College
        http://www.mvac.org/