The American University in the Digital Age

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Introduction

Several months ago, I experienced a transition from a university president to a "virtual" university president--in a sense that will become more apparent toward the end of my talk today. While I am in this virtual state, a limbo between the purgatory of a university presidency and the heavenly pleasures of a university faculty position, I thought I had better bring myself back up to speed on the nature of today's students. It was in that effort that I was a bit taken back by a flyer I spotted in my academic building 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. Next they will learn object-oriented C++ programming, including DOS graphics calls, while creating stand-alone Windows NT applications with menus, dialog boxes, and graphics. They will explore computer graphics and animation, including still imagery and video with MacoMedia Director and Photoshop. They will use these tools to explore the technological fields of robotics and artificial intelligence. "

Sounds pretty advanced for college students, doesn't it? Perhaps. But this was not directed toward college students. Instead it was an advertising brochure for a summer camp run by the Michigan College of Engineering for high school students of ages 13 to 17!

Needless to say, not only is the technology of computers and networks driving change in our world, but it is also changing substantially the knowledge base of the students we will be teaching. From a broader perspective, we find that four important themes are converging in the final decade of the 20th Century:

1. The importance of the university in an age in which knowledge itself has become a key factor in determining security, prosperity, and quality of life;

2. The global nature of our society;

3. The ease with which information technology–computers, telecommunications, and multimedia–enables the rapid exchange of information; and

4. Networking, the degree to which informal cooperation and collaboration among individuals and institutions are replacing more formal social structures, such as governments and states.

These themes of change present both great challenges and opportunities to the university.

The Age of Knowledge

Today our society is undergoing a dramatic shift in fundamental perspective and structure. We are experiencing a transition in which intellectual capital--that is, brain power--is replacing financial and fiscal capital as the key to our strength, prosperity, and social well-being. The key element in this remarkable transformation is the emergence of knowledge itself as the new strategic commodity, as important as mineral ores, timber, and access to low-skilled labor were at earlier times. But, of course, this new commodity knows no boundaries. It is generated and shared wherever educated, dedicated, creative people come together. And, as we have learned, it spreads very rapidly.

A Communications-Driven Society

In Michigan, in the industrial midwest, we have a unique vantage point from which to view a particularly important feature of these changes. If there was one sector that most strongly determined the progress of the twentieth century, it was *transportation* and its related industries--cars, planes, trains, oil, space. Transportation determined prosperity, national security, even our culture--with the growth of the suburbs, international commerce, and so on. During this period Michigan's automobile industry had no equal, and the state rapidly became one of the most prosperous and powerful industrial regions on earth. Today things are very different. We have entered a new era in which the engine of progress is not transportation but rather *communication*, enabled by the profound advances we are now seeing in computers, networks, satellites, fiber optics, and related technologies. We now face a world in which hundreds of millions of computers easily can plug into a global information infrastructure. Jacques Attali in his profound essay, *Millennium*, suggested that the impact of information technology will be even more radical than that of the harnessing of steam and electricity in the nineteenth 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.

These rapidly evolving technologies are dramatically changing the way we collect, manipulate, and transmit information. Needless to say, the implications for our universities are profound. Let me illustrate with three themes:

Theme 1: The University as a Knowledge Server

One frequently hears the primary missions of the university referred to in terms of teaching, research, and service. But, these roles 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 computer networks, 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 do change–and change 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, in turn, 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 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, unaccustomed and unwilling to learn sequentially–to read the manual–and, rather, 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.

Just watch how a young people surf through the Net for information. They launch search engines, scour Gopher and ftp sites, interact through MOOs and Usenet groups, both following existing links and launching new ones. In a very real sense, they are on a serious journey of learning, building elaborate information networks. It is a highly interactive and collaborative process. This is the way they learn.

Indeed, there is even research that suggests that a physiological difference between the brains of the "digital generation" and those of us from 20th Century generations. More specially, it has been known that early exposure of infants and young children to various stimulation can actually affect their neurological development--the evolution of their neutral networks. Children raised in a media-rich, interactive environment tend to think and learn differently because they are physiologically different from us. Our styles of learning are not theirs.

Hence, 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.

Theme 2: A Shift from Analysis to Creation

The professions that have dominated the late twentieth century--and to some degree, the late twentieth century university--have been those which manipulate and rearrange knowledge and wealth rather than create it, professions such as law, business, accounting, and politics. Yet it is becoming increasing clear that the driving intellectual activity of the twenty-first century will be the act of creation itself.

Perhaps the determining characteristic of the University of the twenty-first century will be shift in intellectual focus from the preservation or transmission of knowledge to the process of creation itself. The tools of creation are expanding rapidly in both scope and power. Today we have the capacity to literally create 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 "life forms" through artificial intelligence and virtual reality.

Hence, perhaps the university should structure itself in a more strategic fashion to nurture and teach the art and skill of creation. Perhaps we should form strategic alliances with other groups, organizations, or institutions in our society whose activities are characterized by great creativity (e.g., the Disney Company?).

Theme 3: Shifting Social Structures

A third theme lies in the implications for existing social structures of knowledge-based organizations such as universities. It is clear that 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.

But here we face a particular dilemma. Both the pace and nature of the changes occurring in our world today have become so rapid and so profound that our present social institutions--in government, education, the private sector--are having increasing difficulty in even sensing the changes (although they certainly feel the consequences), much less understanding them sufficiently to respond and adapt. It could well be that our present institutions, such as universities and government agencies, which have been the traditional structures for intellectual pursuits, may turn out to be as obsolete and irrelevant to our future as the American corporation in the 1950s. There is clearly a need to explore new social structures capable of sensing and understanding the change, as well as capable of engaging in the strategic processes necessary to adapt or control change.

Since the business of the university is knowledge, technology such as computers, networks, ubiquitous computing, knowbots, and virtual reality may well invalidate most of the current assumptions and thinking about the future nature of the university. Some questions will illustrate this:

1. Will a "university of the 21st Century" be localized in space and time, or will it be a "metastructure", involving people throughout their lives wherever they may be, on this planet or beyond?

2. Is the concept of the 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?" Will intelligent software agents roam far and wide through robust networks containing the knowledge of the world and instantly and effortlessly extract whatever a person wishes to know?

3. Will lifestyles in the academy (and elsewhere) become increasingly nomadic, with people living and traveling where they wish, taking their work and their social relationships with them?

Yet, despite the profound nature of these questions--and potential impact on higher education--there is a certain paradox here. Few faculty seem to understand or appreciate these issues. For the past several months I have been working with the National Science Board and the Government-University-Industry Research Roundtable to hold town meetings for faculty on a number of university campuses across the country. Among the many issues felt to be of major importance to their universities and their own activities, information technology was conspicious in its absence.

The Digital Age

The Evolution of Information Technology

It is clear that information technology is evolving very rapidly. In the next several years we will see yet another 10,000-fold increase in the power of computers and networks. Yesterday, in fact, Silicon Graphics announced a new, massively parallel computation server running at “teraflop” speed--that is, operating at one million-billion operations per second. Indeed, efforts are underway to build a “petaflop” supercomputer, with a million times more computing power than today’s machines. Within several years, widely available international networks capable of point-to-point multi-media (including video) will be available. Wide-area networks in the gigabit-per-second range will be in routine use, although still well short of the 25,000 gigabit potential of third generation fiber optic technology. Wireless communication will support remote computing and communication.

Already a modern $1,000 notebook computer has more computing horsepower than a $20 million supercomputer of the late 1980s. And the evolution of this technology is still on the trajectory predicted by “Moore’s Law”, that the

computing power for a given price doubles every 18 months. Software is also evolving rapidly, with new genetic algorithms that improve themselves with age. As networks threaten to overwhelm us with a knowledge-rich environment, we beginning to use intelligent software "agents" as our personal interface with the digital world, with the capacity to roam the electronic globehunting down answers to any question or request we may have.

The Nature of Human Interaction

The most dramatic impact on our world today is not in the continuing increase in computing power. Rather it is in a dramatic increase in "bandwidth", the rate at which we can transmit digitial information. From the 300 bits-per-second modems of just a few years ago, we now routinely use 10 megabit-per-second local 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.

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. But with the rapid development of sensors and robotic actuators, touch and action-at-a-distance will soon be available. Further, 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 (MUDs and MOOs). Indeed, 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 "avatars", to interact in a virtual world with those of our colleagues.

Ubiquitous Computing

Here is an interesting exercise. Think through your day's activities, from the moment you awake until you return to bed at the end of the day, and try to identify the various ways that you encounter computers. While most of us first think of the trusty old work-station on our desktop, it doesn't take much further reflection to realize that we are surrounded by computers. Our radio-alarm clock contains a computer. Our watch is really a computer with a timing circuit. Our house is chocked full of computers--they control the temperature, make our coffee and toast, tune our television. So, too, the modern car is more computer and electronics these days--at least by cost--than it is metal and plastic. Our pager and cellular phone are computers. Our workplace is filled with computers. Even our credit-card has become a tiny computer, capable of tracking our expenditures.

In fact, information technology--computers, telecommunications, and such--is rapidly becoming ubiquitous, disappearing into the woodwork, just as electricity

did a century earlier. Today we don't look for the wires to hook a light bulb up to a power source. Rather we just throw a switch (or perhaps just enter a room that senses our presence), and the light goes on. So, too, with chips with supercomputer power and high bandwidth networks now becoming cheap commodities, information technology is becoming so pervasive in our everyday life that it is becoming invisible, taken for granted even as we become more dependent upon it.

Perhaps the ultimate example of ubiquitous computing will be the myriad of computers and networks that attach themselves to us to extend our personal capabilities. At some point our very nervous system may plug into the Net. Whether or not eventually it evolves into a Neuromancer/Snowcrash blend of physical space and cyberspace, it is clear that our natural and electronic experience will increasingly blend.

Changing Lifestyles

Information technology has already stimulated profound changes in our lifestyles. We already sense the loosening constraints of space and time. Many of us have already discarded the burden of the daily commute in favor of "telecommuting" via our computer, modem, and fax. Others are finding that they have become tethered to their workplace with the electronic umbilical cord of pager and cellular phone. Electronic mail, voice mail, and fax are rapidly replacing "snail mail". And whether a university department, a commercial enterprise, or an individual, all are increasingly identified not by phone number or address but rather by the URL of their Website (e.g., http://www.milproj.umich.edu/).

Other aspects of our daily activities have changed dramatially. In the digital age, economic activity is driven by the bit business, producing, transforming, distribution, and consuming digital information. In fact, the physical marketplace is rapidly disappearing, while "virtual" marketplaces based on networks and computers--are emerging as the site of economic activity. Yet here there is an important difference. Digital information is unlike any other type of economic good--natural resources, human labor, property--in the very interesting respect that it cannot be used up. In fact, use actually multiplies rather than diminishes digital products. Further, digital products can be reproduced an infinite number of times with perfect accuracy at zero cost! Hence the concepts of property, copyright, patents, and laws--all based on physical manifestations--simply do not apply. (Perhaps the same might also be suggested about contemporary lawyers...)

The Need for Agents in a Knowledge-Rich World

This tendency of digital information to multiply and propagate rapidly through digital networks can also be a challenge. Already the vast scale of the Internet and the access it provides to vast storehouses of information threatens to overwhelm us. As anyone who has "surfed the Net" can testify, it is easy to be amused but usually difficult to find exactly what you need. Further, living and

working in a knowledge-rich--indeed, knowledge-deluged--world will overload our limited human capacity to handle information.

Hence it will become increasingly necessary to depend on intelligent software agents to serve as our interface with the digital world. Many already use primitive constructs such as filters for electronic mail or web-crawlers to search through databases on the Net. But with the use of artificial intelligence and genetic algorithms, one can imagine intelligence agents dispatched by a user to search the digital networks for specific information. Further, these agents can also represent their human user, serving as "avatars", in mediating the interaction with the agents of other human users.

There are a couple of interesting possibilities here. Since software agents are each to reproduce, one can imagine a cyberspace quickly flooded with billions of agents--similar to the software viruses that can propagate through and cripple computer systems. Further, there is already evidence of "wars" between software agents, where agents from one group of users seek out and destroy those from others. But perhaps the most profound evolutionary stage will occur when the distributed processing power of networks allow the appearance of "emergent behavior", in which agents begin to exhibit self-organization, learning capability, and intelligent behavior. Perhaps the predictions of science fiction, of HAL 9600 or Neuromancer, that we may be unable to distinguish which of our colleagues in cyberspace are flesh-and-bones and which are silicon, is only decades away.

The Bitsphere

The most important feature of information technology is its ability to release people and their activities from the constraints of space and time. The Internet, the World Wide Web, and their successors are evolving rapidly into a global digital network, what William Mitchell, Dean of Architecture at MIT calls a "bitsphere", interrelating people and their activities through robust, albeit ubiquitous, computers, networks, and intelligent hardware and software. As Mitchell puts it in his provocative book, *City of Bits*, this will be a community "unrooted to any definite spot on the surface of the earth, shaped by connectivity and bandwidth constraints rather than by accessibility and land values, largely asynchronous in its operation, and inhabited by disembodied and fragmented subjects who exist as collections of aliases and agents."

The bitsphere will be an international community, with physical infrastructure and users scattered widely across different polititals and cultural units, increasingly free from the norms and laws of nation-states. Because its electronic structure is so modular, geographically dispersed, and redundant, the bitsphere is essentially indestructable. Indeed, its antecedents were design to withstand nuclear attack. It grows and propagates like weeds in a field rather than a carefully planted and nurtured crop.

This worldwide electronically mediated environment in which networks are everwhere, and most of the artifacts that function within it have intelligence and

communications capabilities will pose great challenges to traditional societal institutions. But it will also create extraordinary opportunities. Nations that seek to remain economically competitive and prosperous will race to invest in the new electronic infrastructure, just as in the past they have invested in public infrastructures such as railroads, highways, and airports.

The Implications for Higher Education

Imagine the reactions of a 19th Century physician, suddenly transported forward in time to a modern surgery suite, complete with all of the technological advances of modern medicine. The ancient physician would recognize very little--perhaps even the patient--and certainly would not be able to function in any meaningful way. Contrast this with a 19th Century college professor, transported into a contemporary university classroom. Here everything would be familiar; the same lecture podium, blackboards, students sitting in rows, ready to take notes. And even the subjects--literature, history, languages--would be familiar and taught in precisely the same way.

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 which were supposed to drive radical change--television, computer-assisted-instruction, wireless communications--have bounced off the classroom without a dent.

Yet, 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 the new technology to cut the bonds of space and time? Is it its ubiquitious nature? No, rather 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.

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. 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. Although there have been efforts to broadcast such instruction through "sunrise semester" efforts, augmented by written correspondence, the more effective approach utilizes onsite teaching assistants to work directly with the students. More recently,

technology has allowed the use of feedback via electronic mail, two-way video interaction, or groupware such as Lotus Notes.

The simplest conception of the virtual university proposes using 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, in which the instructor and the students would be interacting together. But 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.

The initial driving force behind the formation of virtual universities is related both to cost and market. 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 even have been some early efforts by for-profit entities to enter the higher education marketplace through virtual university structures, thereby competing directly with traditional colleges and universities.

Learning Communities

However, many believe that effective computer-network-mediated learning will not simply be an Internet extension of correspondence or broadcast courses. John Seeley Brown of Xerox Parc suggests that this model of the virtual university overlooks the nature of how university-based learning actually occurs.

He suggests that it is a mistake to think of learning as information transfer, the act of delivering knowledge to passive student receivers. Rather learning relies on social interactions. More specifically, Brown suggests that learning is rooted both in experience and social interaction. It requires the presence of communities.

This is the value of the university--to create learning communities, and to introduce students into these communities. Undergraduates are introduced to communities associated with academic disciplines and professions. Graduate students and professional students are involved in more specialized communities of experience and expertise. Brown even suggests that one of the important roles of the university is to certify through the awarding of degrees that students have had sufficient experience with a variety of communities and that they have learned the rudiments of community joining.

Distance Learning Paradigms

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. Rather, the key is to develop computer-

mediated communications and communities that are released from the constraints of space and time.

First, we should recognize the importance of asychronous learning. Although face-to-face conversation is both local geographically and synchronous temporily. But throughout human civilization, the advantages of asynchronous communication have been recognized. In asynchronous communications, words are not heard as they are spoken but repeaked at some point later. This allows thought and consideration to mediate the asynchronous communication.

Such asynchronous interactions are ideally suited to the Net, since it allows low cost ways to hold many-to-many conversations among people who are distributed in both space and time. Indeed, beyond simple interactions through E-mail and bulletin boards, role-playing games such as MUDs, MOOs, and MUSEs seem ideal for learning. These software constructions not only provide a virtual environment where interactions occur, but also provide common objects for participants to observe, manipulate, and discuss. That is, the Net provides both a medium for conversation and for circulating digital objects.

Further, such Net-mediated communities allow open learning, in which the student decides when, where, and how to interact with the learning community.

Unbundling the University

The modern university has evolved into a monolithic institution controlling all aspects of learning. In a sense, the faculty decides what it wants to teach, how it wants to teach it, and where and when the learningwill 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.

The most significant impact of the Net, of computer-mediated learning, 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 "student-centered", they may well find it necessary to unbundle their many functions, ranging from admissions and counseling to instruction to certification. Brown suggests that the successful university should aim for three things:

1) To enable students to engage in open learning, exploration and knowledge creation;

2) To provide the resources to help them work in both distance and campus-based learning environments

3) To offer them the means to earn exchangeable equivalent credentials for work done in class, on-line, or through hands-on experience.

Indeed, he suggests that we might consider the total breakup of university functions. Separate degree-granting bodies (DGBs) would be small administrative bodies setting degree requirements and core courses. Faculty would become independent contractors, working for DGBs to provide educational services. Students would be able to choose DGBs, faculty, and campuses. A student's academic career would not be through a particular place, time, or group, but rather through a network of their own making, yet endorsed by the DGB and the faculty.

The Need for Experimentation

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

Experiment #1: The School of Information

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 thought about launching a "skunkworks" operation to explore and develop various paradigms for what a 21st Century university might become. Rather than building an independent research center, we instead 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.

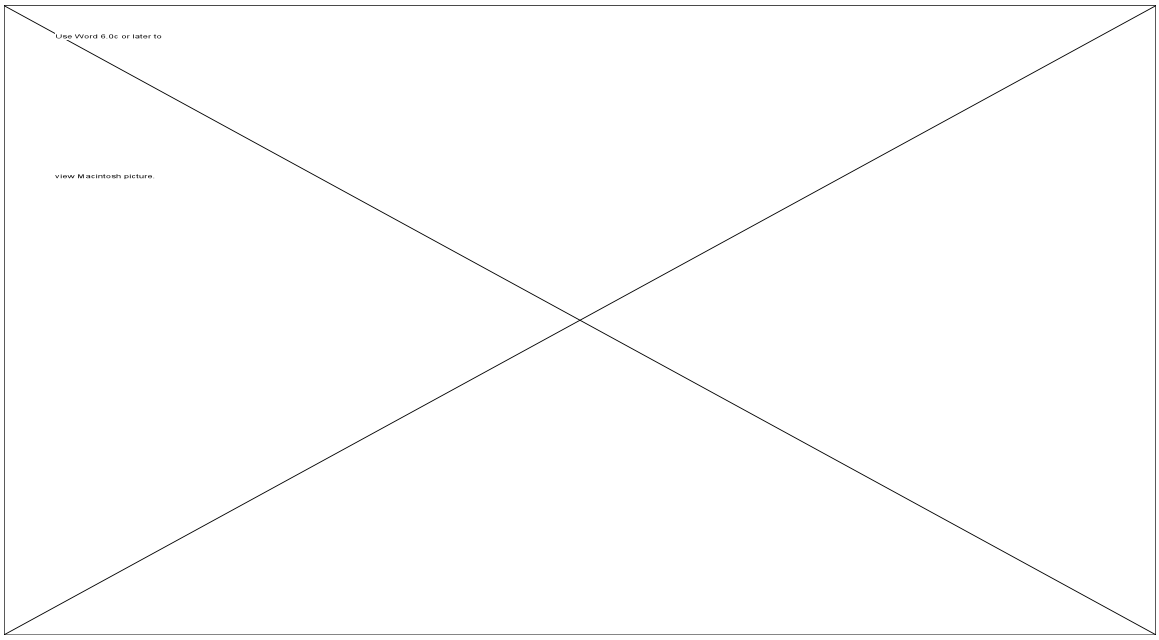
Put simply, this school is committed to developing leaders for the information professions who will define, create, and operate facilities and services that will enable users to create, access, and use information they need. It intends to lead the way in transforming education for the information professions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

Experiment #2: The Media Union

At the University of Michigan we have launched just such an experiment: a fascinating new center known as the Media Union. It is designed to be a laboratory, a testbed, for developing, studying, and perhaps 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.

The Media Union creates an environment where students and faculty can join with colleagues beyond the campus, developing and testing new visions of the university, exploring teaching, research, service, extension, and other areas. Even more importantly, the Media Union fosters a new spirit of excitement and adventure. It provides the foundation for a risk-tolerant culture, where students and faculty are strongly encouraged to "go for it," accepting failure as a part of the learning process as they reach for ambitious goals. Organized around dynamic, integrative themes, the Media Union works to break down the compartmentalized nature of the larger university.

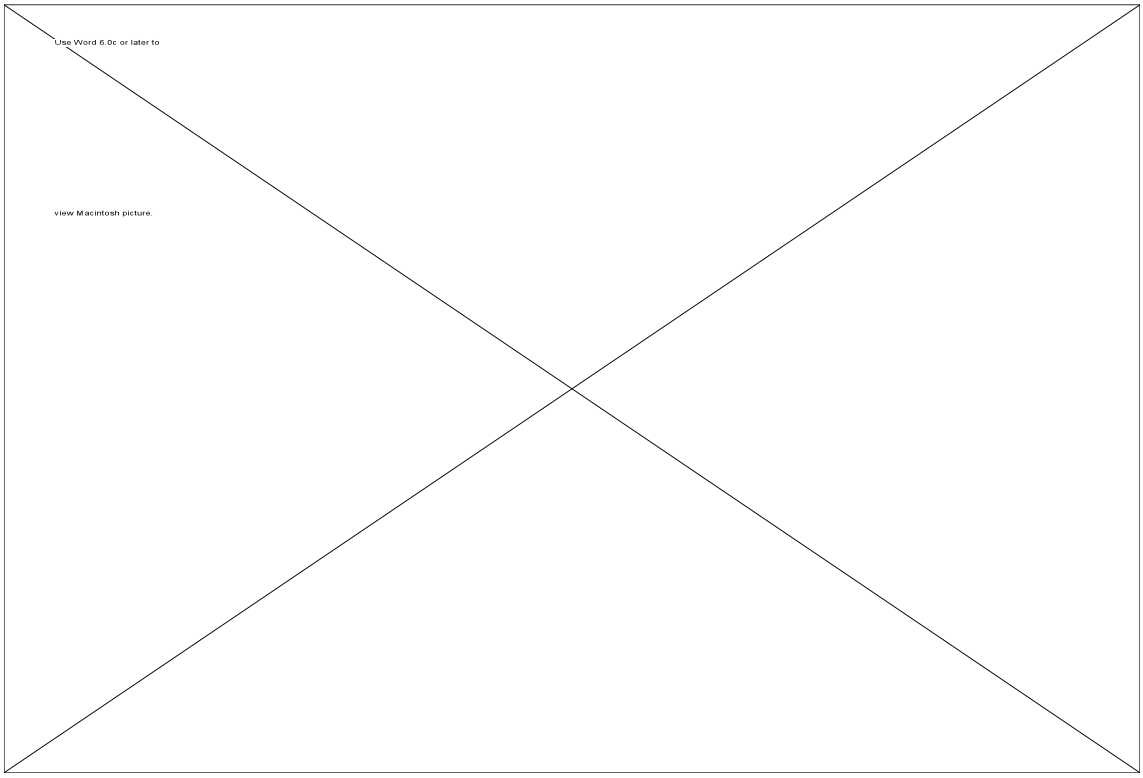


The University of Michigan Media Union

More specifically, this 250,000 square-foot facility, looking like a postmodern version of the Temple of Karnak, contains almost 1,000 workstations for student use--including 200 Mhz Pentiums and Macs and Unix machines such as Suns and Hewlett Packard workstations. It has thousands of more network jacks for students to plug in their laptops--or wireless modems if they wish to work in its surrounding plazas and gardens during the summer. The facility contains both a 1,000,000 volume science and engineering library, but perhaps more significantly, it is the site of our major digital library project. There is a sophisticated teleconferencing facility, design studios, visualization laboratories, and a major virtual reality complex with several CAVEs. 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.

The Media Union is a facility open 24 hours a day, 7 days a week, primarily designed for students. (There is only one faculty office in 250,000 nsf complex.)

Perhaps the best way to envision the Media Union is as a tremendous interactive playground for imaginative scholars, a place for creativity—using knowledge to serve our society. The tools in the Media Union are designed to be so easy to use that they become natural extensions to everyday activity.



The Millennium Project

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 innovation in teaching, research, outreach, and administration. In a sense, we hope the Millennium Project functions as a "skunkworks", whose hanger doors will open every so often, and something strange but wonderful will be wheeled out and flown away. The first such experiment will be the Michigan Virtual Auto College.

Experiment #3: The Michigan Virtual Auto College

Even as I speak today, we are filing the articles of incorporation for the Michigan Virtual Auto College. 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 is being formed as a private, not-for-profit 501 (c) 3 corporation that will broker technology-enhanced course and training programs for the automobile industry including the Big Three and Tier 1, 2, and 3 providers. The MVAC will serve as an interface between higher education institutions, training providers, and the automotive industry. It will work 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 will eventually serve as a platform for the State of Michigan to build an education export industry.

The MVAC is a college without walls. Courses and programs can be offered from literally any site in the state to any other technologically connected site within the state, the United States, or the world. While it will be incorporated in Lansing, Michigan, the headquarters for MVAC are temporarily located in Ann Arbor, with permanent offices likely to be at a site in Detroit.

Although technologies are rapidly emerging, it is expected that MVAC will, during the pilot phase, broker courses which utilize a wide array of technology platforms including satellite, interactive television, Internet, CD-ROM, videotape, and combinations of the above. The MVAC will seek to develop common technology standards between and among providers and customers for the ongoing delivery of courses.

The MVAC will offer courses and training programs, ranging from the advanced post-graduate education in engineering, computer technology, and business administration to entry level instruction in communications, mathematics, and computers. For example, the first round of pilot courses to be launched in February include:

Community College Level:

- Failure Mode Effects Analysis
- Gage Repeatability and Reproducibility
- Introduction to Taguchi Methods
- Gap Analysis for QS-9000
- Internal Quality Auditing

University Level:

- Design for Assembly
- Understand the Internet and Intranets
- Fluid Flow and Visualization
- Life Cycle of Polymers and Composites
- Experimental Design in Engineering
- Foundations of System Engineering
- Applied Geometric Dimensioning and Tolerancing

Initial funding at a level of $675,000 has been provided by the Michigan Jobs Commission for the planning stage. The startup capital will be roughly $1 million from UM, MSU; $3 million from the automobile industry; and $5 million from the state of Michigan, all over a three-year period. However it is anticipated that MVAC will, after a limited period of time, be fully self-sustaining.

The schedule for the MVAC is an aggressive one, with formal incorporation in November and delivery of the first array of pilot courses by February, 1997. We hope to have a full curriculum in place by Fall of 1997.

Concluding Remarks

Many view the computer as a symbol of the depersonalizing nature of modern science and technology. Yet, if ever there was a tool for empowering the individual, it is information technology. This has become truly a liberating force in our society, not only freeing us from the mental drudgery of routine tasks, but linking us together in ways we never dreamed possible, overcoming the constraints of space and time. In part, it is our challenge collectively as scholars, educators, and leaders to build greater public understanding and support for this extraordinary tool, which is so key to our nation and the world as we prepare to enter the age of knowledge that is our future. We are on the threshold of a revolution that is making the world's accumulated information and knowledge accessible to individuals everywhere. This has breathtaking implications for education, research, and learning. It is a profoundly democratic revolution which must and which will involve us all.

There is an increasing sense that the bitsphere will not permit business-as-usual for most universities. Rather it will demand radical changes in the institutional arrangements among students, faculty, and educational institutions.

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. But as true learning communities are constructed in cyberspace, traditional educational institutions will feel increasing competition and pressure to change.

It is ironic that the cyberspace paradigm of learning communities, in reality, represents a mechanism to return higher learning to the historic ways of the university, with 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.

Liberal arts colleges that continue to stress such mentoring, hands-on, tutorial-based education will be least challenged by the bitsphere. But large, comprehensive universities, relying heavily on impersonal mass education, are at

great risk, since a significant share of 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.

However, those universities which understand their strengths in building learning communities, providing students with the capacity to interact and learn within these communities, and then certifying the learning process may well find the coming digital revolution an extraordinary opportunity. Universities that understand both their unique role and the profound nature of the new technology could well evolve into truly global institutions, using the bitsphere to provide educational services to an increasingly knowledge-dependent world.

A Final Observation

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 can well make the case the it has become the responsibility of democratic societies to provide their citizens with the education and training they need throughout their lives, whenever, whereever and however they desire it, at high quality and at a cost they can afford.

Just as with electricity, that soon became a necessity of life and therefore the responsibility of a society, today education itself has become a similar need.

Fortunately, today's technology is rapidly breaking the contraints of space and time. It has become clear that most people...in most areas...can learn and learn well using asynchronous learning technology. The barriers are no longer cost or technology but rather perception and habit.

Perhaps, just as electricity became so ubiquitious that "only the rich still burn candles', perhaps "asynchronous education--that is, "anytime, anyplace" education-- will one day become so commonplace that ony the rich will still rely on conventional schools.

Perhaps lifetime education will soon become a reality, making learning available for anyone who wants to learn, at the time and place of their choice, without great personal effort or cost.

Perhaps this is the real future for the American university in the digital age.