The Academic Workplace of the Future
The Impact of the Internet

Changes in the economy and in the global community are placing demands on higher education that will lead to basic changes in the structure, purposes and priorities of colleges and universities and their relationships with the broader society. Internet2, a consortium of about 200 universities with partners in industry and government is developing and deploying advanced network applications and technologies that are contributing to these changes. It is interesting that the implications for K-20 education were hard to place in the task groupings that have built up around Internet2 since the issues spread across the whole enterprise, but it landed in initiatives with a task as follows:

“to bring to Internet2 member institutions, primary and secondary schools, colleges and universities, libraries and museums new technologies applications, middleware and content of innovators, across all educational sectors in the USA as quickly and as connectedly as possible...in order to enhance teaching and learning by facilitating projects that explore ways in which advanced network applications, services, tools and digital content can extend access to education and educational services.”

- Partnerships
- Initiatives
- Applications in the domains (telemedicine, astronomy, remote instrumentation)
- Engineering
- Middleware
Higher education is no longer the primary source of intellectual authority nor do most of its students learn primarily in environments designed by the faculty and directed by them. The hierarchical structure of knowledge and its related intellectual structure within higher education institutions are inappropriate for a society where everyone can have access to information and knowledge by entering cyberspace. Learning is spreading throughout society.

As access to the production and use of knowledge becomes more democratic, what will be the new societal responsibilities that higher education should assume? The role of higher education will be to provide coherent ways of learning and to retain the connection between individual learning and the public good. The traditional role of scholars as transmitters of knowledge will be replaced by the concept of preceptors who offer interpretations of what it means to be educated and who counsel and assist students in obtaining knowledge, skill and competencies from a variety of experiences and sources. In addition, faculty will be expected to model in their own conduct what it means to be educated and to generate and use knowledge responsibly. Higher education can serve as a compass or a gyroscope in the rapidly shifting and unstable environments in which students find themselves.

The moral authority enjoyed by higher education comes from the trust that is placed in its integrity by the public. Who can now confer that authority and how can we earn the public’s trust? Most of us trust people we know and can see. Can we trust someone in cyberspace? If so, how?

In attempting to obtain public support, higher education has painted itself into a corner by asserting its economic value, both
for individuals and for the larger society at the expense of continuing its claim to the preservation and advancement of democracy through its role in promoting social responsibility and the “public learning” that generates the capacity to address complex social and community issues.

Observations

- Information technology is transforming both our society and our social institutions (Jim Duderstadt, *Higher Education in the Digital Age*) by changing how we create, manage, transfer and apply knowledge.
- The key resource for economic prosperity is knowledge, well-educated people and fresh ideas, not raw materials or space. Governor Sanford of South Carolina was quoted in a recent David Broder column (The Washington Post National Weekly Edition, Feb 16-22, 2004) as saying that the old economic model for the South was based on “cheap land, cheap labor and right-to-work laws that discouraged unionization.” This worked well for 50 years when the competition for business was New England or the Upper Midwest but with the advent of globalization, businesses looking for cheap labor or cheap land will go to China or India or Nicaragua.
- Similarly, a computer programmer in the U.S. costs IBM $56 an hour while a programmer in China earns $12.50 an hour. (*CSM* February 17, 2004. p. 8 editorial on Shipping Out White-Collar Jobs)
- In theory, at least, companies that save money on higher end workers will invest more heavily in new technology, in turn creating more jobs in this country. The future may involve R&D jobs in this country and skilled labor in other countries.
• The U.S. is just beginning to work out strategies for retooling displaced workers who lose jobs to white-collar outsourcing abroad.

• These patterns affect the very nature of scholarship and how knowledge is created, preserved, interpreted, transmitted and applied (Duderstadt 2002. Even more fundamentally, technology is changing the relationship between people and knowledge and will, in ways we cannot yet predict, reshape the societal role of higher education and its relationship to the other educational and knowledge providers in society.

• Carl Raschke (2003, The Digital Revolution and the Coming of the Postmodern University) argues that society will no longer think of universities as they place where knowledge is "manufactured." He proposes that the nature of knowledge is fundamentally changed when the social infrastructure for the allocation of knowledge is radically altered. This is what is meant by a knowledge revolution. It will affect the institutions in which knowledge is housed, processed and "transmitted" or "distributed," namely colleges and universities. The loss of elite authority will shatter disciplinary boundaries and change who asks questions, who answers them and who determines what is legitimate and what is not.

• Students who have access to technology are demanding different educational experiences. They do not learn in an orderly and sequential fashion and they do not learn passively. They plunge in and figure things out through experimentation. They also help shape cyberspace environments through the ground rules of on-line gaming, for example.

Technology is reshaping educational environments.
1. Increasingly, Americans are differentiated not by whether they have access to Internet but by what they do on-line and how skillfully and intensively they do it.

2. Almost all of our K-12 schools have internet access (99%) and most of our classrooms do (87%) but these resources are rarely utilized effectively.

3. Fundamental changes in school organization, time management and teacher preparation will be needed in order to generate the most value from this massive investment in technology. These changes will affect what students and teachers do in the classroom. Similar changes are taking place in higher education.

4. When fully used, Cyberinfrastructure (CI) represents a suite of enabling tools essential to the study of complex systems and to the modeling of real-world behaviors of these systems for learning purposes. It includes collaboratory software, visualization tools, data-mining capacity and data management techniques and the support of geographically distributed sensing systems and observation sites that generate enormous amounts of data to be assimilated and interpreted using knowledge representation and manipulation software.

5. CI can be used to see into the classroom and to examine the pathways by which individual students explore ideas and acquire mastery of material. The challenges of an educational context open up new areas of research for the designers of CI and cybertools and often generates new research questions. It also permits investigators to deal
with the enormous data sets created by multimedia observations of classrooms, individual student learning and scientific observations.

6. **CI can help us teach difficult and important material that requires more sophisticated modeling, simulations and visualization.** It allows us to examine continuous, dynamic, simultaneous, organic, interactive, conditional, heterogeneous, irregular, nonlinear, deep, multiple processes that are difficult to understand.

7. **The work sponsored by NSF has served to disclose to learners mathematical and scientific phenomena in ways that static, textual or symbolic representations simply cannot do,** revealing that young people who often have difficulty learning scientific concepts from textbooks and lectures can often do extremely well when given challenging content in new ways.

8. **The development of computer software has also opened a number of doors in designing improved instructional materials.** The following are some dominant themes in the proposals we have received: Interactive materials (computer tutoring). There are some powerful “smart” tutoring systems being beta tested that hold out the promise of improving the individualization of learning. Mastery learning (a combination of trial problems and then on-line tests demonstrate mastery). Simulation of laboratory or field settings, e.g. simulating an archaeological dig, or an economic market, or a chemistry experiment. The visualization aspect of simulation is often the most important contribution. A growing fraction of grants are making use of simulation technology.
9. The use of the Internet, digitized learning, simulation and remote access via advanced networks (distance learning) can help professionals cope with the rapidly growing body of knowledge they must absorb and use by promoting education, research and day-to-day interactions that advance knowledge and its introduction into practice.

Example: Orthopaedic knowledge compounds in a manner similar to money invested at a 12% interest rate, doubling every 6 years. This means that during a typical career in orthopaedic surgery, knowledge will double six times.¹

Surgeons can use streaming video to observe procedures, access large image collections such as the Visible Human and use haptics (teleoperations) to sense remove actions.

10. The growing availability and more sophisticated use of technology in both K-12 and in higher education will act as a disruptive technology by changing the nature of the relationships and roles played within our educational environments. It will change

a. How knowledge is created and by whom
b. Who defines what is worth knowing
c. Who controls access to information and who interprets it
d. What it means to learn and what it means to teach
e. Who is an active participate and who simply observes

11. The use of cybertechnology holds up a mirror to our faculty and challenges them to revisit their own assumptions about their role in learning, their intentions and goals for themselves and for their students. It permits them to engage their students directly in exploring material in the ways of their disciplines. Instead of a faculty member assimilating and interpreting a field, the whole thought process is laid open and students gain more control over the subject matter.

12. The most powerful effect of cyber-experience may not be in the things people do on the web or with broadband communication but rather how they think and what they expect from education. People who innovate and create in cyberspace will not be likely to sit still, literally, for a lecture.

13. We really do not know much about what it means to understand something and whether cyberspace helps or hinders this process. It has become increasingly clear that representations such as those used in graphing the patterns generated by algorithms are differently perceived by people who know what the functions mean and those who do not. Experts see one thing. Inexperienced students see something else. The deeper we probe, the more we find out about what is already imbedded in our own thinking and interpretation of what goes on around us. It is necessary to break up those assumptions and familiar patterns if any new ideas are to be absorbed and learned.

14. Learning has been defined as the formation of new patterns and connections to reflect new experience. Would that this were really easy. In fact, new material presented
either in person or graphically or virtually is often memorized but not assimilated or absorbed. In the midst of developing new educational killer apps, we would do well to take time to find out what people actual see, how they interpret what they see and whether these new things in cyberspace can work well without the physical experience that other forms of exploration bring.

Is anybody looking at how people learn in cyberspace or what happens when real environments and virtual spaces are brought together as a mixed space?

Has anyone looked at what happens to learning or understanding when human senses and physical capacities are extended through visualizations and haptic sensations? Do I understand the structure of a virus better if I can “feel it?” Can I appreciate the latest findings in the cosmos if the images are color enhanced? What does the human brain and body do when it is separated from its usual inputs and connected to a virtual space?

In a recent op-ed piece in the CSM (March 26, 2004, p. 9), Joan Silverman argued that “to truly grasp the printed word, you gotta hold it.” She reads the daily news on-line, bypassing the paper edition altogether. Then it dawned on her that the physical pleasure of holding a book or a newspaper

...“the creamy off-whites, dull grays, and print that’s more complementary than contrasting” ...“assists in her understanding.” She wonders if “we read as carefully or as thoroughly as we do in print, and whether our attention is divided by the medium itself.”
Well worth thinking about.

At the same time, cyberspace may offer opportunities that ordinary learning in a classroom or in a workshop or laboratory cannot. Consider for example the self-organizing environment of on-line gaming and how the natural test of competence unfolds as people offer modifications of the open source codes that shape the space. What can we learn from this? What will students expect from formal education if they have such accountable freedom in cyberspace?

Is there a meaningful difference between performing an experiment on real growing plants in a greenhouse or setting conditions for a simulation? If so, how can we draw from the strengths of both?

What kind of community are we forming in the environments created by high end computing and networking? What will citizenship in this community mean? How many communities might we belong to and how will that affect our own sense of identity and belonging?

Does it matter whether you learn alone or in a community of other learners or, if you are a professional, in a community of practice? What is different about a conversation in person, a series of exchanges on line, a set of short instant messages on a computer screen or on a cell phone?

You have helped set a large societal change in motion, but like many other such times in history, we might type out for ourselves, “What hath God wrought?”
Technology and advances in scholarship will also reshape the research community. This will have broad implications for the undergraduate curriculum and for graduate study.

- The nature of research itself is changing as several forces converge: nanoscale science, cyberinfrastructure and remarkable advances in computing power and speed, genomics and proteomics and cognitive sciences. As these fields merge, they are creating new capacity to enhance human and social performance and leaving the traditional undergraduate curriculum behind.

- What is really happening to the scientific community, how it is organized, who interacts with whom, what kinds of science are being done and how it is being done?

- In the information age, a library is less devoted to the collection and preservation of knowledge and more a “center for knowledge navigation, a facilitator of knowledge retrieval and dissemination (Duderstadt 2002).

- New computer capacity will allow us to move from one world to another (Ideas from the Institute for Human and Machine Cognition, U. Western Florida). The effect on the curriculum and how we prepare our students will be profound as our understanding of fundamental processes improves.

World One: discrete, static, sequential, mechanistic, separable, universal, homogeneous, regular, linear, superficial, single
World Two: continuous, dynamic, simultaneous, organic, interactive, conditional, heterogeneous, irregular, nonlinear, deep, multiple.

- As this happens, the areas of greatest interest transcend traditional academic disciplines and the structure of the academic department and draw increasingly from many disciplines. The structure of the undergraduate major as well as courses for general education have not kept pace with these developments.

- Example: The NRC Report Bio2010 shows that “[t]he connections between the biological sciences and the physical sciences, mathematics and computer science are rapidly becoming deeper and more extensive.”(p. 1) To compound the changes even more, scientists now take advantage of cyberspace to interact with each other differently, to gather and interpret their findings and to communicate their work in new ways.

- Is any of this new way of doing science and communicating about science reflected in the curriculum and in the experiences of undergraduates? Not much! According to Bio2010, the teaching of biology has not changed substantially in over two decades. Meanwhile, the science itself has undergone a remarkable transformation. The gap between the biology that students study and the realities of the most exciting and advanced work in the life sciences is a matter for deep concern.

Many traditional aspects of higher education institutions will need to be reshaped and must take on new functions as students change their patterns of enrollment and their
expectations. Access and opportunity will take on new forms and present new challenges. We must learn to deal with the instability created by both the changes in the professoriate and by the complex enrollment patterns now increasingly common among students.

• Few traditional age (18-26 year old) obtain their education from one institution (source Cliff Adelman Principal Indicators of Student Academic Histories in Postsecondary Education, 1972-2000. U.S. Department of Education

1. 57% attend more than one school as undergraduates
2. 35% cross state lines to do so
3. 20% earn acceleration credits by examination or dual enrollment
4. 62% attend during summer terms
5. 22% are stop-outs and 14% are enrolled for less than a year
6. Of those who earn more than 10 credits, 64% earn a credential of some kind.

• Pathways through higher education are now very complex. Of the 57% who attended more than one institution:

• 26% attended two or more 4-year schools
• 9% were true reverse transfers
• 22% transferred from a 2 year to a 4 year
• 14% alternated between 2 and 4 year schools
• 12% took a few community college credits in addition to attending a 4 year school
• 11% attended two or more community colleges
• This leads to the concept of pathways of educational attainment rather than pipelines.

**Pipeline:** a clear and uninterrupted route from high school to college and from college to advanced study

**Pathways:** complex patterns of enrollment that involve more than one institution

• The professoriate is also destabilizing as fewer than 25% of new faculty are hired into tenure-track positions. The proportion of the professoriate that is full-time and tenured has dropped steadily since the 1980's. Part-time and fixed term faculty are much more likely to carry heavy teaching loads and are unlikely to contribute in other ways to the institution in the form of either scholarship or service.

• Institutions are structured along intellectual lines and each is a self-contained academic environment that prescribes its own course of study, the desired sequence of coursework and its own requirements for graduation. However, our students increasingly do not obtain their entire educational experience at one institution. While 91% of high school graduates from high-income families apply to four-year institutions, only 62% of college-qualified high school graduates from low-income families attempt a four-year college education. Many of these lower-income students come from socio-economic groups that are much less likely to complete a degree even if they do enroll in college.
• A higher proportion of Hispanics enroll than do non-Hispanic whites. However, they tend to pursue paths that are associated with lower chances of attaining a bachelor's degree or a higher degree. Many enroll in community colleges or attend part-time and others delay further education until they are older. This is also true for African-Americans and Native Americans.

• The pattern of participation of underrepresented students in higher education is partly driven by cost, partly by reactions to the culture of academic disciplines and partly by the lack of access to social networks that smooth the way into college.

What about students who travel on pathways rather than progress through pipelines? We need to explore some educational questions that very few people appear to be addressing.

• What do pathway students study?
• What are their educational goals and do their goals change as they progress?
• How can we promote greater success for students who take pathway routes through higher education? What Federal and state policies might we consider and how might we implement them to ensure access, quality and affordability?
• What kind of education do pathway students obtain? Does it make sense?
• If a pathway education does make sense, what makes that possible?
• What public policies might smooth movements across institutions and enhance the intentionality
and integrity of the curriculum that pathway students encounter?

- How can we close the gaps in participation and outcomes for different participants in our educational system?

**What will the university of the future be like?**

It is worth thinking about Carl Raschke’s ideas of the Hyperuniversity.


**Bottom line:** We must examine what it will mean to be educated in the 21st century, what knowledge is and will be, how knowledge will be created, interpreted and who will have access to it, how learning opportunities will be distributed through society and who will have access to learning.