The Future of the University in the Digital Age

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Introduction

I would like to

…make three points concerning the impact

of information technology on the future of the research university

…and then duck as the debate erupts

To summarize my three points at the outset:

1) The exponential evolution of digital technology is likely to continue

For at least the foreseeable future.

It will drive rapid, profound, unpredictable, and discontinuous change

It is a "disruptive" technology.

It erodes…indeed obliterates conventional constraints

Of space, time, and monopoly

It reshapes the boundaries of institutions

2) Digital technology will not only transform the activities

of the university--our teaching, research,

outreach, but as well it will transform

how we are organized, financed, managed

…even whom we regard as students and faculty.

It could well lead to a restructuring of

the current higher education enterprise

into a global knowledge and learning industry

3) As universities attempt to grapple with the

challenges and opportunities presented by

the digital age, they should focus first on

the fundamentals...their values, roles, and missions

...determining first what they need to strive to retain,

and then how they need to change to protect these characteristics.

Background

My remarks today are shaped in part by my role as chair of a major study launched a year ago by our National Academies of Science, Engineering, and Medicine to better understand the implications of rapidly evolving information technology for the future of the research university.

The steering group for this effort consists of several of your colleagues, including

Nils Hasselmo
Frank Rhodes
Joe Wyatt
Marye Ann Fox
Shirley Jackson
Ralph Gomery

The steering group also consisted of leaders from the IT industry (including the chief technical officers of IBM, Lucent, Xerox, and Internet2, as well as experts in federal research and technology policy.

My comments today draw on this effort and reflect the growing consensus developed during the first year of this project.

Stating the Obvious

Let me begin by stating the obvious:

Higher education has entered a period of significant change as our universities attempt to respond to the challenges, opportunities, and responsibilities facing them in the new century.

The forces driving change in higher education today are many and varied:
the globalization of commerce and culture,
the lifelong educational needs of citizens in a knowledge-driven, global economy,
the exponential growth of new knowledge and new disciplines,
and the compressed timescales and nonlinear nature of the transfer of knowledge from campus laboratories into commercial products.

Of particular importance is the impact of information and communications technologies on the university.

Modern digital technologies such as computers, telecommunications, and networks are reshaping both our society and our social institutions.

These technologies have vastly increased our capacity to know and to do things and to communicate and collaborate with others.

They allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways.

They allow us to form and sustain communities for work, play, and learning in ways unimaginable just a decade ago.

Information technology changes the relationship between people and knowledge.

It is likely to reshape in profound ways knowledge-based institutions such as our colleges and universities.

Of course higher education has already experienced significant change driven by digital technology.

Our management and administrative processes are heavily dependent upon this technology.

Research and scholarship are also highly dependent upon information technology, for example, the use of computers to simulate physical phenomena, networks to link investigators in virtual laboratories or "collaboratories," and digital libraries to provide scholars with access to knowledge resources.

There is an increasing sense that new technology will also have a profound impact on teaching, freeing the classroom from the constraints of space and time and enriching learning by providing our students with access to original source materials.

Yet, while information technology has the capacity to enhance and enrich teaching and scholarship, it also poses certain threats to our colleges and universities. We can now use powerful computers and networks to deliver educational services to anyone, at anyplace and anytime, no longer confined to the campus or the academic schedule.

Technology is creating an open learning environment in which the student has evolved into an active learner and consumer of educational services, stimulating the growth of powerful market forces that could dramatically reshape the higher education enterprise.

While most believe the university will survive the digital age, few deny that it could change dramatically in form and character.

Knowledge is both a medium and a product of the university as a social institution.

Hence it is reasonable to suspect that a technology that is expanding our ability to create, transfer, and apply knowledge by factors of 100 to 1,000 every decade will have a profound impact on the both the mission and the function of the university.

The NAS Project: The Impact of IT on the Future of the Research University

In the United States, the National Academies (i.e., the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine) have a unique mandate to monitor and sustain the health of the nation's research universities as key elements of the national research enterprise and the source of the next generation of scientists, engineers, and other knowledge professionals.

This role becomes particularly important during periods of rapid change. It was from this perspective that last year the presidents of our National Academies launched a project to understand better the implications of information technology for the future of the research university.[1]

The premise of the National Academies study was a simple one:

The rapid evolution of digital technology will present many challenges and opportunities to higher education in general and the research university in particular.

Yet there is a sense that many of the most significant issues are neither well recognized nor understood either by leaders of our universities or those who support and depend upon their activities.

The first phase of the project was aimed at addressing three sets of issues:

1. To identify those technologies likely to evolve in the near term (a decade or less) which could have major impact on the research university.

2. To examine the possible implications of these technology scenarios for the research university: its activities (teaching, research, service, outreach); its organization, structure, management, and financing; and the impact on the broader higher education enterprise and the environment in which it functions.

3. To determine what role, if any, there was for our federal government and other stakeholders in the development of policies, programs, and investments to protect the valuable role and contributions of the research university during this period of change.

Over the last year our steering group has met on numerous occasions to consider these issues, including site visits to major technology laboratories such as Bell Labs and IBM Research Labs and drawing upon the expertise of the National Academy complex.

This past January we pulled together over 100 leaders from higher education, the IT industry, and the federal government, and several private foundations for a two-day workshop at the National Academy of Sciences to focus our discussion. (This workshop was broadcast by the Research Channel and is now available through video-streaming from their Web servers.)

Beyond the insight brought by these participants, perhaps even more striking was their agreement on a number of key issues that frame the content of my remarks this morning.

So much for background. Now back to my three points:

Point 1: The extraordinary evolutionary pace of information technology will not only continue for the foreseeable future, but it could well accelerate on a superexponential slope.

For the first several decades of the information age, the evolution of hardware technology followed the trajectory predicted by "Moore's Law"—a 1965 observation by Intel founder Gordon Moore that the chip density and

consequent computing power for a given price doubles every eighteen months.[2] Although this was intended to describe the evolution of silicon-based microprocessors, it turns out that almost every aspect of digital technology has doubled in power roughly every 12 to 18 months, with some technologies such as photonics and wireless technology evolving even more rapidly.

Put another way, digital technology is characterized by an exponential pace of evolution in which characteristics such computing speed, memory, and network transmission speeds for a given price increase by a factor of 100 to 1000 every decade.

Of course, speculation about the evolution of this technology is frequently wrong. We tend to overestimate the near term … and seriously underestimate the long term …in part because we tend to extrapolate what we know about the past and the present for a technology which is characterized by disruptive surprises, so-called "killer apps" such as the personal computer, the web browser, and Napster.

With this caveat in mind, consider just a few data points:

A new generation of supercomputers has come on line, so-called terascale computers, capable of performing over one trillion calculations per second. Computers a hundred times faster under are currently under development for applications such as the calculation of protein folding.

New displays are capable of resolutions which are noticeably better than paper, and next generation interfaces may use retinal displays in which lasers paint images directly on the retina of the eye to achieve 360 degree immersive environments.

Bandwidth is continuing to increase rapidly, with 100 Mb/s local area network access routine and 10 Gb/s network backbones common, with G-3 and G-4 wireless technologies providing ubiquitous connectivity.

Applications software is advancing rapidly, stimulated by new software paradigms such as genetic algorithms and new forms of collaboration such as open source development (e.g., Linux).

Already the Internet links together hundreds of millions of people, and estimates are that within a few years, this number will surge to billions, a substantial fraction

of the world's population, driven in part by the fact that most economic activity will be based on digital communication.

By the end of next year over 90% of homes and 98% of schools in the United States will be connected to the Internet.

Bell Laboratories suggests that within two decades a "global communications skin" will have evolved, linking together billions of computers that handle the routine tasks of our society, from driving our cars to maintaining our health. (Indeed, the current slogan at Bell Labs is "Fiber to the forehead")

Put another way, over the next decade, we will evolve from "giga" technology (in terms of computer operations per second, storage, or data transmission rates) to "tera" and then to "peta" technology (one million-billion or 10^{15})[3].

To illustrate with an extreme example, if information technology continues to evolve at its present rate, by the year 2020, the thousand-dollar notebook computer will have a data processing speed and memory capacity roughly comparable to the human brain.[4] Except it will be so tiny as to be almost invisible, and it will communicate with billions of other computers through wireless technology.

For planning purposes, we can assume that within by the end of the decade we will have infinite bandwidth and infinite processing power (at least compared to current capabilities).

We will denominate the number of computer servers in the billions, digital sensors in the tens of billions, and software agents in the trillions. The number of people linked together by digital technology will grow from millions to billions.

We will evolve from "e-commerce" and "e-government" and "e-learning" to "e-everything", since digital devices will increasingly become our primary interfaces not only with our environment but with other people, groups, and social institutions.

Point 2: The impact of information technology on the university will likely be *profound, rapid, and discontinuous*–just as it has been and will continue to be for the economy, our society, and our social institutions (e.g., corporations, governments, and learning institutions).

For at least the near term, meaning a decade or less, we believe the research university will continue to exist in much its present form, although meeting the challenge of emerging competitors in the marketplace will demand significant changes in how we teach, how we conduct scholarship, and how our institutions are financed.

Over the longer term this technology will drive very significant restructuring of our society and social institutions through what John Seely Brown and Paul Duguid[5] term the 6-D effects of *demassification, decentralization, denationalization, despecialization, disintermediation*, and *disaggregation*.

Perhaps we should also add a seventh "D", *democratization*, since digital technology provides unusual access to knowledge and knowledge services (such as education) hitherto restricted to the privileged few. Like the printing press, this technology not only enhances and broadly distributes access to knowledge, but in the process it shifts power away from institutions to individuals.

Universities must anticipate these forces, develop appropriate strategies, and make adequate investments if they are to prosper during this period.

Procrastination and inaction are the most dangerous courses for colleges and universities during a time of rapid technological change.

Point 3:. It is our belief that universities should begin the development of their strategies for technology-driven change with a firm understanding of those key values, missions, and roles that should be protected and preserved during a time of transformation.

They should begin by addressing the most fundamental questions:

For example, how should the research university set priorities among its various roles such as
education of the young,
preservation of culture,
basic research and scholarship,
serving as a social critic,
and applying knowledge to serve society?

Which of its values and principles should be preserved, and which should be reconsidered, e.g.,
academic freedom,
openness,
critical thinking,
sustaining a community of scholars,
our commitment to excellence,
shared governance, and
tenure?

How will research universities define their students?
As the young?
As adults?
As established professionals and perhaps even academics?
The best and brightest?
Members of broader society?
The workforce? On a local, national, or global level?

How will we define our faculty members?
As the products of our graduate schools and research laboratories?
As practicing professionals (a la University of Phoenix)?

What is the role of the residential campus in a future in which knowledge-based activities such learning become increasingly independent of space and time (and perhaps reality?)

How should the research university address the rapidly evolving commercial marketplace for educational services and content, including, in particular, the for-profit and dot.com providers?

What policies does the university need to reconsider in light of evolving information technology (e.g., intellectual property, copyright, instructional content ownership, faculty contracts)?

Will new financial models be required? Beyond the need to implement a sustainable model of investment in information technology infrastructure, the intensely competitive marketplace for higher education services stimulated by digital technology will put at risk the current system of cross-subsidies in funding university activities.

Just-in-time lifelong learning and the growing desire to be educated anyplace, anytime are driving the demand for distance education. How should the university approach the challenges and opportunities of online distributed learning?

What is the role of universities with respect to the "digital divide", the stratification of our society–our world–with respect to access to technology?

Will more (or perhaps most) research universities find themselves competing and collaborating in a global marketplace, and how will that square with regionally supported universities?

Will new learning lifeforms or ecologies evolve based upon information technology that will threaten the very existence of the university?

Preparing for Change

Although any recommendations concerning how to respond to the challenges of such an uncertain future should always be regarded with some skepticism, certain general observations seem relevant:

1) While learning and scholarship requires some independence from society, it is nevertheless important to listen carefully to the many stakeholders of the university, to learn their changing needs, expectations, and perceptions of higher education, and to understand the various forces driving change in our world. This conversation also provides a context for decision-making during a time of rapid, technology driven change.

2) Since the future will become increasingly uncertain, universities should encourage experimentation with new paradigms of learning, research, and service by harvesting the best ideas from within the academy (or elsewhere), implementing them on a sufficient scale to assess their impact, and disseminating their results.

3) Furthermore, they should place a far greater emphasis on building linkages and alliances that will allow individual institutions to focus on their unique strengths while relying on alliances to address the broader and diverse needs of society.

Conclusion

The digital age poses many challenges and opportunities for the research university.

While the university campus as a physical place, a community of learners, and a center of culture, is likely to remain at least for the near term, the nature of its activities, organization, management, and funding are likely to change quite rapidly and dramatically.

1) Emerging competitors in the commercial sector could threaten our current financial models.

2) We will be challenged to attract and retain outstanding students and faculty members in the face of competition from institutions with superior technology environments (including the commercial sector).

3) The status quo will certainly be challenged by this "disruptive" technology.

Yet, while the challenges will be significant, so too will be the opportunities to enhance the important role of the university in our society.

We suggest that university leaders should approach issues and decisions concerning information technology not as threats but rather as opportunities.

Creative, visionary leaders can tap the energy created by such threats to lead their institutions in new directions that will reinforce and enhance their most important roles and values.

They can use digital technology to help their students learn more effectively, to help their faculty members to become better teachers and scholars, to enable their institutions to better serve society–and, indeed, the world itself.

It is our collective challenge as scholars, educators, and academic leaders to develop a strategic framework capable of understanding and shaping the impact that this extraordinary technology will have on our institutions.

> We are on the threshold of a revolution that is making the world's accumulated information and knowledge accessible to individuals everywhere, a technology that will link us together into new communities never before possible or even imaginable.
>
> This has breathtaking implications for education, scholarship, and learning and, of course, for the university in the digital age.

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[1] The co-principal investigators of the National Academies project are William A. Wulf, President of the National Academy of Engineering and Professor of Computer Science at the University of Virginia and James J. Duderstadt, Professor of Science and Engineering at the University of Michigan. Raymond E. Fornes, Associate Vice President for Research at North Carolina State University, has served as the senior Academy staff member for the project.

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

[3] Put another way, a petabyte of data is roughly equivalent to the capacity of a stack of CD-ROMs nearly 2 km high.

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

[5] John Seely Brown and Paul Duguid, *The Social Life of Information* (Harvard Business School Press, Cambridge, 2000).