

University Alert

The Information Railroad Is Coming

The rapid evolution of information technologies presents universities with numerous challenges and opportunities that are not well understood by either academic administrators or their faculty. William Wulf, president of the National Academy of Engineering, believes that much as the arrival of the railroad fundamentally altered small, regional industries, the information railroad will transform the intellectual activities of universities and the way they are organized, financed, and governed. He predicts profound, rapid, and discontinuous change—not only in the execution of the mission of universities but in our perception of their mission as well. Wulf urges engagement in open, honest discussions to help understand the implications of technology for higher education.

The Pace of Technological Change

It is extremely difficult to comprehend the compound effect of information technology's exponential rate of improvement. During the past four decades, the speed and storage capacity of computers have doubled every 18 to 24 months; reductions in cost, size, and power consumption have occurred at about the same pace. The bandwidth of computer networks has increased even faster—a thousand-fold in just the last decade—and traffic on the Internet continues to double every 100 days.

Consider this: ENIAC, the first fully electronic digital computer, contained about 18,000 vacuum tubes and weighed 30 tons. Today, a holiday card that plays a tune when opened is 100 times faster than the ENIAC. It costs about \$2 and is intended to be opened once or twice and then discarded!

Experts believe that the extraordinary pace of in-

formation technology evolution will not only continue for the next several decades but is likely to accelerate. Although the exponential pace of change cannot go on forever, the slowdown is not on the horizon and, more important, is not going to spare us from rethinking the university.

Ironically, although we can predict the improvement of technology with great precision, predicting the societal impact of that improvement has been difficult. Perhaps the wisest course of action may be imagining a range of scenarios that might result. While none of them may be exactly as anticipated, the exercise of devising responses to these scenarios will improve our ability to respond to what actually happens.

Exploring the Possibilities

We can begin a discussion about the implications of technology for higher education by looking at several

functions of universities and noting how they have been or might be changed.

Scholarship

The impact of information technology on scientific research is pervasive. Scientists now routinely talk of computation as the “third modality” of scientific investigation, on par with theory and experimentation. The obvious examples are applications that simply automate what used to be done manually: reduction of data, control of instruments, and so forth. The truly profound applications are those that lead to entirely new areas of research and new methods of investigation—and thus to science that was not, and could not have been, done before: analyzing molecules that have not been synthesized, watching a model of galaxies collide, measuring the properties of a single neuron by growing it on a silicon chip, and so on. These sorts of applications have transformed the nature of scientific investigation.

I believe, though, that an even more dramatic transformation is about to shake the foundation of scholarship in the liberal arts. Humanists more than scientists will lead the way to innovative applications of technology in the university. The availability of both texts and images in electronic form, coupled with the processing power of modern computers, allows the humanist to explore hypotheses and visualize relations that were previously lost in the mass of information sources. Precisely because of the complexities of the relationships humanist scholars need to present, electronic hypertext books and journals are emerging. Indeed, they are emerging faster, with more vigor, and with more effect on their disciplines than their counterparts in the sciences. We are also witnessing a shift in the sociology of scholarship, for example, from individuals to teams of scholars.

The work being done at the Institute for Advanced Technology in the Humanities (IATH) at the University of Virginia demonstrates the possibilities in this realm. IATH was founded in the early 1990s to explore how information technology could be used to support humanistic scholarship. A tour of the institute is available through IATH’s World Wide Web site: www.jefferson.village.virginia.edu.

Textbooks

No one I know would rather read from a screen than from a book. Besides, you cannot take a computer to the beach—or so some say. This attitude, though, assumes that electronic books will contain only text and hence will be essentially the same as paper books except in method of presentation. In reality, it will not be possible to reproduce an electronic book on paper. Electronic books will not be simple linear presentations of static information. Among many other features, electronic books will contain animation, sound, and multidimensional links so you can navigate through the information in ways that suit your purpose rather than the author’s. They won’t contain references to sources but rather the source material itself—a critique of a play, for example, could be accompanied by its script and excerpts of its performance.

Another mistaken assumption often made in regard to electronic books is to envision them using today’s technology and today’s screens. In fact, flexible “digital paper” of nearly the same resolution as the paper you are reading right now already exists in the laboratory. Why would anyone lug around several heavy books when something the size, clarity, and weight of a single one contains them all? I do mean *all*—all the books in the Library of Congress. I *will* take my computer to the beach!

Libraries and Books

For thousands of years, libraries have served largely as containers of information, namely, books. The principal objective of librarians has been to build the collection—to amass a set of materials by which to measure the library’s worth. In the future, libraries will not collect. Electronic information can be communicated virtually instantaneously, so its source location is irrelevant. Instead of a hoarder of books, the library must become the facilitator of retrieval and dissemination.

If we project far enough into the future, the library and the book will merge as hypertextual links to build a seamless web that will doom the discrete, isolated volume. Parts of library collections will be active, functioning as software agents by collecting, organizing, relating, and summarizing on behalf of their human authors. They will “spontaneously” become deeper, richer, and more useful.

Accompanying the merger of the book will be a merger precipitated by devolving disciplinary boundaries. Knowledge is not inherently compartmentalized; there is only one nature, one human record. Disciplinary divisions are an artificial human imposition, one mirrored in paper texts. The practical reasons for disciplinary structures evaporate in the electronic world. Although disciplines are complex and idiosyncratic social structures that will not easily dissolve, I believe that much of the most interesting scholarship today is taking place at the boundary of traditional disciplines. That's not news: Einstein opined

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that most important science lay at the intersections of traditional disciplines. What is new is that we have a technology that facilitates incremental accretion of knowledge at these intersections.

Teaching

Given the current nature of most scholarship and texts, chalk and the overhead projector are perfectly adequate technology for most teaching today. If, however, the bulk of the faculty begins to use information technology in their scholarship and the results can only be exhibited using technology, then the classroom will rapidly follow.

Perhaps the most obvious application of technology is telepresence—the ability to involve remotely sited students in a seminar, for example. As the fidelity of communication improves, the use of telepresence will no doubt increase. But this sort of application is relatively mundane in the sense that it doesn't change the educational process in a deep way. More profound is the op-

portunity to involve students in the *process* of scholarship rather than merely its results. Students can escape the linear sequence of text, course, and curriculum, where they absorb facts, to embark upon scholarly projects, where they can think.

A wonderful example of such change spurred by the use of technology is a project called The Valley of the Shadow, led by the University of Virginia's Edward Ayers at IATH. The project details the lives of some 10,000 people who lived during the Civil War at opposite ends of the Shenandoah Valley, in virtually identical communities except for their location on opposite sides of the Mason-Dixon Line. Richly hyperlinked, The Valley of the Shadow is an invaluable resource for students and scholars alike. It has irrevocably changed Ayers' courses on the Civil War: He can no longer tell a simple linear story because his students have too much access to the real messiness of history. Instead, he now concentrates on the process of historical scholarship, using the Civil War and The Valley of the Shadow as resources.

The University as a *Place*

Historically, the university has been a *place*. Cardinal John Newman's notion that books were an inadequate source of true education and must be buttressed by discourse has been widely accepted for centuries—during most of which such discourse could only mean conversation among individuals in the same location.

I believe that information technology largely obviates the need for the university to be a place, particularly for its research function. Remote scholarship and authoring are the direct analogs of telecommuting in the business world. Large scientific instruments such as telescopes and accelerators are already run by large consortia and shared by faculty from many universities. The physical presence of the investigator is not necessarily required—the instruments are accessible via electronic networks.

As with instruments in the sciences, direct access to archival materials is necessary for some humanistic scholarship—but hardly all, and certainly not all of the time. If anything, the ubiquitous information infrastructure will provide greater access to archival materials to a much

larger set of scholars, of a quality that is wholly adequate for most purposes.

As for teaching, we don't know yet whether it can be successfully distributed electronically, but we must consider the possibility. Although I believe that some level of interaction is necessary, there is a threshold of fidelity beyond which one need not go; students and teachers hardly need to smell each other, for example. Thus, there is some finite amount of information required to produce an adequate representation of the parties. When that threshold

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of fidelity is reached electronically, high-quality teaching *will* be distributed. The fallacy in Cardinal Newman's reasoning was only that he could not imagine quality discourse at a distance—yet that is precisely what technology enables.

Conclusion

Having laid the groundwork for the possibilities, I have more questions than answers as to the new shape of the university of the future. Allow me to pose a few:

- Might we see outsourcing of large introductory courses? If so, what happens to the cross-subsidy from these courses that supports small upper-level undergraduate and graduate courses?
- Does it make sense for every university to support the full complement of disciplines, or should universities

specialize and share courses in cyberspace? This might be a natural consequence of aggregation by disciplinary affinity, for example.

- Might professors affiliate with several institutions or become freelance tutors to telepresent students? Indeed, might we return to the future of tele-itinerant scholars and tutors?
- Might some employers (and hence students) eventually prefer transcripts that list who taught each course rather than where each course was taken?
- Will universities merge into larger units akin to the corporate world, or will the opposite occur? On one hand, one can envision many small colleges empowered to offer broad curricula via telelocation. On the other hand, one could argue that the current size of most universities is optimized for its physical infrastructure, not for either education or scholarship purposes.

Our challenge is to anticipate and exploit the inevitable changes on the horizon. The questions posed here are not meant to be threatening; rather, they are intended to stimulate open conversation. The university is simply too important to our society to evade such discussion. Instead, dispassionate contemplation of the possibilities and careful examination of our often unstated assumptions are the best course for preserving the critical functions universities provide for our society.

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