TECHNOLOGY'S TRANSFORMATION OF THE UNIVERSITY

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THE RECENT TREMENDOUS ADVANCES IN THE USE OF computer networks as tools of inquiry, including the growth of free communication links among scientific researchers and practitioners around the world, have resulted in a less stifling organizational hierarchy, a loss of governmental controls, and an ethic of sharing information instead of commercializing it. Technology, it seems, has created a new set of tools to facilitate research. The most exciting and important changes in society will not come simply from the use of machines such as computers but from the unlocking of information such as the DNA code by utilizing technology.

Communications technology has also linked the information resources of the globe. But as one connects in new ways, one also abandons old connections. Thus, although new communications technologies are likely to strengthen research in general (and medical research in particular), they will also weaken the traditional methods of education. Instead of prospering with the new tools, many universities will have their traditional functions superseded, their financial bases eroded, and their roles in intellectual inquiry reduced. This transformation will not be limited to universities because many major institutions of society will

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also be affected. For example, studies on the banking industry demonstrate that many commercial banks are in deep trouble because of the Information Revolution: What is worse, many are unaware of the problems they face.

Higher education has three primary functions: conducting research and evaluating its validity, preserving information, and passing that information on. Accomplishing each of these functions is based on a set of technologies and economics. Changing the technology means that the economics, the primacy of these functions, and the institutions must also change.

THE UNIVERSITY AS A SOURCE OF INFORMATION

Information institutions date back 5,000–8,000 years, a time when priests emerged as specialized preservers and producers of information. They also served as the primary information storage receptacles of their societies. Eventually, recording methods emerged, writers were trained, and schools appeared. Writing led to information storage institutions. Under one Assyrian king, the Royal Library stocked over 10,000 works. In these libraries, documents were arranged in separate rooms by subject matter. Wise men congregated in the new libraries to use the information and to add to it. Knowledge and inquiries were organized along lines strikingly similar to today's university departments.

This model of centrally stored information with a wide range of subjects grouped under one institutional roof was logical when information was scarce, reproduction expensive and restricted, and specialization low.

Perhaps the best illustration of this model is the most formidable information institution of antiquity, the Great Library of Alexandria. At its peak, this library amassed nearly 700,000 volumes, many of them medical treatises. Less recognized is the role of this library as a graduate university. From its inception, it recruited some of the foremost scholars of the region, such as the geometrician Euclid. These scholars were surrounded by disciples and apprentices who adored them, cleaned up after them, and supplemented their salaries, which were never high enough. They were joined by other scholars who came to the information storage, produced still more information in collaborative efforts, and hence attracted more students and disciples.

INFORMATION TECHNOLOGY: THREAT OR SALVATION

This system of higher education remained remarkably stable for over 2,500 years but is now in the process of breaking down. The reason is not primarily technological, since technology merely enables change. Rather, the fundamental reason is that today's abundant production and rapid distribution of information is undermining traditional methods of information flow and thus the university structure itself. That structure is poised to collapse in slow motion should alternatives to its functions be found.

A major reason for this possible collapse is the systematic imbalance in the information environment. Since World War II, the production of information in the U.S. economy has increased at a rate of about 6 percent, and the growth rate itself is rising rapidly. Distribution of information is growing even faster by an estimated 10 percent or more. However, reaching a similar growth rate for the processing of information by individuals and organizations has proved difficult. This situation has serious implications for a wide range of institutions. (Indeed, virtually all aspects of society are affected by this imbalance and by the ensuing attempt to adjust the individual and processing rates of information to the demands that growth in the other stages have put on them.)

An example of the recent information explosion is the rapid proliferation of available scientific texts. It took *Chemical Abstracts* thirty-one years, from 1907 to 1937, to print its first one million abstracts. The second million abstracts were printed a mere eighteen years later. The most recent million took only one and three-quarter years. Thus, more articles on chemistry have been published in the last two years than in humankind's entire history before 1900.

Organizational response to this increased volume of information has been to try to improve processing capabilities by hiring more people, particularly more highly educated people, reorganizing internally, and investing in technology. However, the main strategy has been to break the information down by subject matter for use by specialists. Nowhere is this better illustrated than in the medical profession, where there are now dozens of specialty fields and probably hundreds of subspecialties. (There is nothing new about specialization; the Bible tells us that Adam's sons specialized, one in agriculture and the other in hunting.)

As specialization has grown, so has the means to create an invisible college

of specialists. Just as air transport established the jet-setting professoriate, so are communications technologies creating new electronic communities that respond to the basic need for collaboration. Ironically, the university pays for the network that helps its resident professors shift their focus outside the university and join virtual communities in cyberspace. Along the way, the advantages of physical proximity of the researchers and professors to their respective universities, as well as to each other, decline even more rapidly.

For most universities, the volume of information doubles every five to ten years. Thus, for the university to keep up with all the work, research and specialization would also have to double every five to ten years. This situation is neither economically nor organizationally sustainable. Universities can no longer cover a wide range of specialties. They might still have a wide range of departments but can only offer a limited set of subspecialties. For that reason, the specialist finds fewer similarly specialized colleagues on campus for the purpose of collaborative work. Because interaction increasingly occurs with physically distant specialists, the university no longer functions as an institutional setting for collaboration.

The function of the university as a physical repository of information is also in jeopardy. It has been said that a university is only as good as its library, but here, too, economics and technology are changing everything. To return to the previous example: In 1940, Chemical Abstracts cost $12 per year, in 1977 it cost $3,500, and in 1995 it cost $17,400.

Comprehensive library collections have become unaffordable at the same time that electronic alternatives have become powerful in storage ability, broad in content, and efficient in retrieval. Therefore, universities are gradually shifting from investment in the physical presence of information to the creation or the provision of electronic access. This logical economic and organizational response undermines the fundamental role of the university as the primary location for specialized information. Soon the combination of laptop computer and telephone line will serve just as well as, and often better than, being there, and access to information will be available anywhere at any time.

The teaching function of university departments and professional schools also faces new problems. Given the rapid growth of technology, it is hard to imagine that the current low-tech lecture system will survive. Student-teacher

interaction is already under stress from the widening gulf between the basic introductory teaching level and the specialization of researchers. This interaction also comes with a big price tag, approximately $50 per lecture hour per student at private universities, not counting the public and philanthropic support that most universities receive or the opportunity costs of student's time. Such high prices for face-to-face education are prompting alternative providers of electronically transmitted education to enter the market. Today's students who seek prestigious jobs or enter restrictive professions usually have no choice but to attend a university.

ALTERNATIVE EDUCATION THREATENS UNIVERSITIES

However, universities are only as strong as their control over accreditation and over the public's acceptance of alternative credentials. So if alternative instructional technologies and credential systems can be devised, there will be an outmigration from the classic campus-based medical, professional, and general education. Medical education may be affected less than other areas because so much of this education is skills-oriented in the last years of study. Nonetheless, information transmission in medicine, as well as in virtually all other professional and undergraduate education, could be handled in other ways.

Alternative education possibilities might include videos, such as restored lectures by outstanding scholars, electronic access to interactive reading materials and study exercises, electronic interaction with faculty and teaching assistants, hypertextbooks, video and computer conferencing, and language translation programs. Although the advantages of electronic forms of instruction are often exaggerated by merchants, the superiority of face-to-face instruction is sometimes also romanticized in today's educational environment where students often attend mass lectures in groups of 250 and rarely speak with their lecturers.

Electronic communication also has an economic advantage because it can be provided at a dramatically lower cost than face-to-face instruction. The cost of obtaining a university education is increasing substantially. Last year, the cost rose by 6 percent at public universities and by 5 percent at private universities.

With the price of education so high and demand so great, it was inevitable that alternative providers would enter the market. A curriculum, once created,

could be offered electronically not simply to hundreds of students but to tens of thousands of people around the world at substantially reduced costs. It could be provided, for example, by universities seeking additional revenues in a period of declining cohorts. Universities around the country are entering the distance education business and moving beyond the borders of their traditional service areas. The market for this expanded service includes students with full-time jobs, family obligations, limited mobility, or an impossibly long commute, as well as those in need of specialized courses.

An excellent example is the agricultural satellite network, AGSAT, which lets two dozen colleges of agriculture exchange their course offerings and thereby reduce the duplication of courses from campus to campus. The victims of the reduction in duplication, of course, resist these efforts at cost reduction and the faculty, which tends to define the mission and structure of many institutions, is as resistant to change as any other profession. Some university communities, however, have rejected attempts to add untraditional services. In Maine, when the president of the university system tried to establish an electronic distance college, he became subject to faculty resistance and eventually had to resign.

It does not seem likely that the ultimate providers of electronic education will be universities becoming "televersities." Universities will merely break the ice and legitimize the practice; it will be commercial firms that will capitalize on this opportunity. Textbook publishers, for example, will establish sophisticated electronic courses using the most effective and prestigious lecturers. Already available on video is the Greatest Lecturers series by America's Superstar Teachers, distributed by a company affiliated with the cable TV giant Jones InterCable, which advertises itself as your own private university. The same company also offers courses on its mind-extension university channel.

Moreover, if the university's hold over the accreditation system weakens, our society may witness something like a McGraw-Hill University, which will hand out degrees, certificates, or course credits just as today some companies offer in-house degree programs. If these programs become valued by society for the quality of students admitted, the knowledge gained, and the requirements that must be met, such programs will be able to compete with courses offered at traditional universities and professional schools without the substantial overhead of physical institutions. They may be able to put together an effective

and often-updated teaching package that makes traditional teaching seem boring in comparison.*

UNIVERSITIES: OBSOLESCENCE OR INNOVATION?

If the university's tuition base falters, its foundation will erode. In these days of budget constriction, most universities will not be able to offset tuition losses with more public funding. Universities and professional schools are worried about their viability. For example, teaching hospitals must compete with hospitals that do not have an educational or research component, and the government has reduced assistance for graduate medical education and research. Private donations will need to increase considerably but, if anything, such donations are likely to decline in the future along with the reductions in university centrality in research and teaching.

Of course, there are other good reasons to attend universities. Universities are also about attending football games and mixers. The associated social networking is similarly important. A significant aspect of university experience, social networking could be replicated in other ways as was the case in the thousands of years preceding mass college attendance. It might also be done in much more attractive locations and climates.

Whether universities will encounter problems with obsolescence will vary according to institutions and departments. On the teaching side, the greatest negative effect of new technologies will be at two extremes. On the one hand, mass education courses will be a tempting target for commercial outfits. At the other extreme, invisible virtual colleges of specialists may start to formalize themselves, not simply to communicate but also to offer some apprenticeship programs and certifications electronically. Those courses that attract few specialists will also migrate away from the traditional university environment.

However, types of instruction that fall between these two extremes will probably survive–in particular, those parts of education that are contact- and skill-intensive and therefore continue to demand face-to face instruction.

* This situation mirrors the way *Sesame Street* has raised the expectation level of preschool children: When they come to school, they expect a very lively, structured, edited type of educational experience that few real-life teachers meet.

On the research side of the university, disciplines that do not experience the rampant growth of specialization will be least affected by outmigration. Nonetheless, these disciplines will also be squeezed financially because they will lose subsidies from the parts of the university which are well supported by grants. Most affected will be highly specialized research areas where keeping up with the latest research is critical. Medicine is one such field. Research requiring physical teams and shared equipment will likely continue to be located on one campus, but the university's research unit will connect primarily to government. In effect, the university would exist somewhat like an office park, albeit an office park of semiautonomous units. The university administration is likely to become even more decentralized, being partly run from a distance by telecommuting staff or contractors.

The question is not whether universities will remain important to society, to knowledge, and to health care, but whether the economic foundation of the current system can be sustained in the face of the changed flow of information. Research and teaching will become increasingly important, while that larger institutional setting, the university, will come under pressure.

A NEW EMPHASIS FOR UNIVERSITIES?

Universities and professional schools will have to place new emphasis on the advantages that personal interaction and physical environment offer to education. True teaching and learning are about more than information. Education is based on mentoring, on internalization or identification or role modeling, on guidance, group activities, and peer interaction. Universities are a traditional site where students participate in a rite of passage into adulthood. They are also about attending football games and mixers. The associated social networking is important. The strength of the future physical university lies less in pure information transfer and more in the college as a community, less in wholesale lecturing and more in individual tutorials. In research, the physical university's strength lies in establishing on-campus archipelagoes of specialized islands of excellence that benefit from physical proximity.

Furthermore, universities are becoming more important than ever in their role as validators of information. As the production of information grows expo-

nentially, society requires credible screeners and validators of information. It has entrusted some of that function to the universities, medical and professional schools, and researchers. Society trusts those institutions more than it trusts commercial firms but, of course, the university must be careful to avoid undermining this trust by a creeping commercialization or self-censorship.

New technologies constitute a long-term threat to the central role of universities and their professional schools as research and teaching institutions. To remain viable, these institutions must undertake changes in focus and a more active management of priorities. In the future, universities will need to stress their functional strengths, such as tutorial aspects, while perhaps de-emphasizing information storage functions, to avoid being reduced to a collection of remaining physical functions like the research labs and the football team.