Until very recently, discussions of the crisis in U.S. education centered exclusively on public schools in the United States; higher education has been viewed as almost trouble-free—the best in the world. Today, however, several problems loom. Many states’ budgets for higher education are falling, and some are poised for truly terrifying reductions even as student populations are increasing and becoming more diverse (in age as well as ethnic composition). At the same time, even as resources are shrinking, industries and consumers are demanding more of colleges. Further, a broad shift from manual workers to “knowledge workers” means that students will require more education; high school diplomas no longer guarantee good job prospects. And many predict that job skills will need updating every few years; if so, “lifelong learners” will continue to demand education and retraining throughout their careers. All these changes are straining institutions of higher education to the breaking point.

In this report, we look broadly at the prospects of meeting some of these challenges with a new generation of information technologies. We review and analyze, in particular, the emerging global information infrastructure—the first pieces of which we now see in the Internet and World Wide Web—and the multiple roles they can play in higher education:

• to improve learning and teaching
• to improve the creation of instruction and learning materials
• to create educational communities
• to compete with new providers
• to address policy and planning issues.

IMPROVING LEARNING AND TEACHING

As resources for higher education dwindle, many now look to information technologies to improve productivity by reducing the time, money, and teaching resources needed to help students learn. In the past, distance-learning applications have demonstrated some of the most impressive cost savings. Several lines of evidence suggest that the Web may be the most cost-effective way to deliver distance-learning courses in the future. Classes from the World Lecture Hall Web site, for example, already incorporate a wealth of multimedia material, including lecture overheads and annotations, digitized lecture audio, digital archives of past final exams, pointers to online libraries, and even interactive simulations that can be run at a distance. To support multi-person, multimedia dialogues in real-time, high-bandwidth interactivity will be available soon. The new generation of Internet-based distance-learning courses, therefore, should provide substantially richer learning experiences for students than the current generation does. At the broadest level, an Internet style of learning or instruction delivery will be so common that distance learning will no longer be viewed as a special form of education delivery.

Many applications of information technology in education are aimed at reducing costs. Since Internet and Web tools will continue to drop in cost and increase in functionality for the foreseeable future, information technology should continue to displace more and more faculty labor. Further, what labor cannot be displaced will at least not have to be nearby; the Internet can connect students with faculty and peers as easily as it connects learners with multimedia documents. Eventually, then, most learning will be distance-independent, and the special cases will be those that are geographically bound.

Other applications focus on the “output” side of the productivity equation: helping students learn more or better, or to learn new skills—skills rarely included in higher-education curricula. For example, intelligent tutoring systems, which try to capture in software
much of the reasoning and knowledge of expert tutors, have led to some dramatic improvements in student learning (e.g., SHERLOCK provides four years of on-the-job training in 20 to 30 hours). More-innovative applications of information technology follow a very different principle: Instead of mimicking human tutors, they provide rich, simulated environments that enable students or trainees to practice skills intensively. Although today many of these applications run only on high-powered machines, emerging standards will soon permit them to be accessed by students who might have only low-end machines—and almost any kind of low-end machine, not just those the original application developer envisioned.

While many applications clearly intend to help speed up learning or improve learning of well-defined subject areas, it is much less obvious how others improve educational productivity in any simple sense. Information technology is also a driver of educational reform, not of productivity enhancement—unless “productivity” is redefined to include a wide range of qualitative changes, not just quantitative improvements. Such applications are trying to transform the processes and products of learning. For example, they might exploit new visualization technologies to enable junior students to learn about complex systems that previously only graduate students found comprehensible; or they could foster deeper understanding through inquiry-based learning rather than traditional lectures, or through collaborative learning methods that never existed before high-bandwidth networks.

**IMPROVING THE CREATION OF INSTRUCTION AND LEARNING MATERIALS**

In addition to providing tools for teachers and learners, information technology can help create new instruction and learning material, improve its organization, facilitate access to it, and speed its development. Many parts make up the traditional pipeline for producing educational materials (and intellectual artifacts, in general), but four are central: authors create documents; publishers mainly manufacture and market copies of these products; libraries primarily acquire, store, and distribute copies to the nearby community; and readers consume them. These groups have played relatively stable roles in the publication process for decades, even centuries. However, in-
formation technology is changing their roles; and, equally important, it is transforming the copyright and intellectual-property-rights laws that underpin relationships among the groups.

In the simplest view of this change, new information technologies will appear to reduce, perhaps even eliminate, the need for publishers and libraries. Traditional academic publishers have approached the Internet very reluctantly, because the Web calls up their worst nightmare: They sell one copy of a digital book, then all others are produced for free with a few mouse clicks. Compared with larger traditional publishing firms, small, grassroots publishers on the Web appear to be more flexible providers of new digital courseware, helping higher education to meet the rising need for “just-in-time” or “on-demand” learning just as information technology already helps manufacturing and services industries dramatically shorten production cycles.

Providing a location and supporting tools that encourage faculty not only to create new online course materials but to share them with others, Web sites such as the World Lecture Hall already demonstrate some of this flexibility. Because the Hall is implemented as a Web homepage, all materials from a course can be downloaded, with minimal effort, from the Hall site to the browser’s home machine. This copy can be edited into a new course, possibly one for a slightly different topic and audience, using simple digital cut-and-paste tools. The new version can be returned to the World Lecture Hall, adding again to the materials available to be shared with the academic community. Eventually, this kind of “chaotic cooperation” might lead to a vast collection of digital courses of progressively better and better quality, as a new generation of course creators stands on the shoulders of the current creators.

This kind of highly informal cross-institutional collaboration has been common in academic research. But, in the past, most higher-education institutions have been much more reluctant to share their course offerings, informally or otherwise. Individual academic publishing, therefore, may stress or even transform existing institutional structures, rather than simply enabling them to operate more productively without fundamental change.
CREATING EDUCATIONAL COMMUNITIES

The World Lecture Hall is one of many new academic and learning communities that are beginning to flourish across the Web. Organized along functional lines, most of these communities are developing courseware, conducting research, and sharing curricula, among other things. Common interests and expertise are much more important in defining these communities than is distance, which is largely erased by cheap, high-bandwidth connectivity. For similar reasons, most cyberspace communities tend to ignore institutional boundaries when those boundaries interfere with emerging functional interests. These factors are beginning to give rise to new communities of practice that, at the very least, crisscross previous structures and, in the extreme, can erode old higher-education structures while building new ones.

Virtual universities, a few of which already exist as prototypes, may be the most extensive (and certainly most publicized) examples of electronic communities. Not extensions of existing institutions, some of the most comprehensive virtual universities on the Internet have been created in cyberspace almost from scratch. Although they by no means rival their traditional counterparts in faculty size or range of courses, online universities such as Athena are beginning to put together digital versions of all the familiar pieces of a campus. Like a typical university, Athena grants liberal arts degrees, has a transfer-credit policy, and offers a detailed and surprisingly traditional core curriculum—quite consciously an attempt to capture in a virtual version the best of traditional university structure. Athena differs substantially from most higher-education institutions only in its admission policy (because finite resources such as classroom space are not an issue, enrollment is open and unlimited) and its teaching methods.

Unlike Athena, a few groups are viewing cyberspace as an opportunity to rethink the structure of educational institutions from the foundations up, rather than as a new tool for an existing organization. The Globewide Network Academy (GNA), one such experiment, is, in a broad sense, a mix of Athena and the World Lecture Hall. Like Athena (and unlike the World Lecture Hall), GNA offers more than just a collection of online courses; it also includes virtual discussion lounges, where teachers, students, administrative and
support staff, and technical experts can engage in ongoing electronic discussions about the academy. The student lounge also contains a collection of links that constitute an ad hoc digital library, and another set of links to career resources. Like the World Lecture Hall (and unlike Athena), however, GNA is not developing its own courses. Rather, it encourages institutions and individuals to list with GNA existing courses for online distance learning, and then provides a collection of value-added and brokering services to help students find the courseware they want and to put them in contact with the providing institutions. At the same time, GNA offers support services for teachers and contributing institutions, which are expected to improve the quantity and quality of the products GNA manages.

In general, higher-education institutions have been reluctant to experiment with more novel designs of a GNA for using information technology: Not only are newer ideas tougher to devise and more expensive to implement, but digitizing old institutions may still seem like a perfectly serviceable, and much more certain, strategy. However, if current higher-education institutions are not interested in conducting high-risk experiments, new external providers of educational services are more than willing to try. If they succeed, they may make clinging to the status quo less and less tenable.

COMPETING WITH NEW PROVIDERS

For decades, providers of education external to traditional colleges and universities have offered a variety of courses and services—from full degrees to short courses and training seminars. Of this sector, the biggest (over $50 billion per year) and certainly fastest-growing (more than 15 percent per year) part belongs to companies that provide corporate training—everything from mastering the nuances of Windows 95 to acquiring much more generic skills in object-oriented programming, analysis, and design. Such courses generally come from external providers specializing in training products that make the heaviest, and often most innovative, uses of information technology.

Higher education’s challenges in competing with these new external providers are, if anything, exacerbated by information technology, not eased. Information technology has helped proprietary providers
reduce delivery costs to the point where even “down-market” (read: higher-education) services can be delivered profitably. Unfortunately, higher-education institutions, as a whole, have not formulated plans to deal with the increasing encroachment of external providers on their turf. They need to.

Several options—only a few of which have been tried seriously—are worth considering. One approach is to shore up defenses against invaders into traditional higher-education markets by erecting protectionist barriers (such as tax supports) that discourage new providers from entering the battle. Perhaps a more positive tactic is to improve productivity in the face of new competition. Many of the enterprises we reviewed—distance-learning campuses and virtual universities, for example—can be regarded as ways in which higher education is already trying to become more productive, sometimes by borrowing models of delivery from the training sector and often by creating innovative models of its own.

A different strategy—to take the offensive rather than honing defenses—is inspired in part by movements of external providers into higher education’s turf. A few institutions are beginning to respond to the challenges posed by external providers by moving, however cautiously, into contract training. This strategy is difficult, however, not only because external providers have a wealth of experience, cash, and technology, but because existing institutional policies often handicap higher education from the outset. For example, whereas business clients frequently expect to be able to mix their instructors with college personnel, college union contracts may forbid hiring external staff.

**ADDRESSING POLICY ISSUES AND PLANNING**

The preceding discussion raises a number of research questions and policy issues about whether applications of the Internet and Web in higher education are technically and economically feasible—and, if so, how institutions should design their technology plans to make best use of these technologies. We focus here on just a few key questions and policy recommendations.
Technical feasibility poses perhaps the greatest barrier to moving higher education onto the Internet and Web comprehensively. Many higher-education institutions are now developing and implementing technology plans for distance learning around technologies with much less functionality than the Web will shortly offer—for example, videotape sent through the mail, one-way TV (over cable channels) augmented with two-way audio (through telephones), or two-way video conferencing using special-purpose hardware. To some of them, a proposal to use the Internet and Web for fully interactive, high-bandwidth, and multimedia courseware must look very premature.

We argue that such a proposal is not premature. Further, we suggest that commercialization, sometimes viewed as a threat to the small academic community that used to be cyberspace, is instead a key to making the necessary broadband infrastructure available both widely and cheaply. To realize this opportunity, however, higher education should take the following steps—and quickly, since windows of opportunity are beginning to close:

- Coordinate technology plans and purchases. The simplest step that higher-education institutions—actually, all educational institutions—should take is to change their model for technology acquisition. Today, schools at all levels buy, piecemeal, hardware, infrastructure, software, and support services for computers and networking. When buying stand-alone computers, this practice is merely unfortunate: Bulk purchases are much cheaper. But when acquiring networking infrastructure, it is a catastrophic error: Networks that cannot interoperate are nearly useless.

- Exploit the Telecommunications Act of 1996. State and federal debates are now setting the stage for regulations that will influence the quantity, quality, distribution, and cost of telecommunication infrastructure and services over the coming decades. This act, signed into law by President Clinton in February 1996, touches on a wide range of issues that pertain to communications giants, electronic publishers, the entertainment media, and
educators. With the act’s passage, many think the best window of opportunity to influence policy in ways that will benefit education is now closed. In fact, the act ignores several critical issues, delegates some decisions, and defers others to later dates. Internet capabilities available to higher education, and their costs, may depend on the outcome of political debates still to come in Washington and the states. To influence these debates, institutions of higher education should unite behind a broad, common vision of their goals and the technology required to achieve those goals.

• Pursue options for inexpensive end-user machines. Even if higher-education institutions can secure the infrastructure needed to supply generous amounts of richly interactive courseware across the Internet, students will still need to interact comfortably and cheaply with these products. Many already can, of course. But if education on the Internet is to be as readily available as education in the classroom, students of all ages will need almost universal access to online courseware. Today, this is not the case, although several options are emerging that might meet this need: Internet appliances may drop in price to a point where most students can afford them, universities could supply machines for students (some already do), libraries and other community services could provide Internet access, manufacturers might consider pay terminals (analogous to pay telephones), and governments could use vouchers as well as other forms of cross-subsidy. The costs and policy implications of these and other potential solutions must be analyzed carefully.

How Will Higher Education Acquire Quality Courseware and Educate Staff?

Universities and students who enjoy lavish Internet capacity will still need quality Web products for learning that make good use of this capacity; in turn, faculty will need to acquire the tools and skills with which to create Web-based distance-learning courseware. Many have argued that the cost of developing new products and providing faculty education will be prohibitive, especially in view of shrinking budgets in higher education. To the contrary, we suggest that much of the necessary training can be accomplished within existing bud-
gets, provided colleges and universities are willing to adopt some of the following creative solutions.

- Use existing tools and training. Many of the tools needed to develop Web-based courseware, and most of the training needed to become proficient with these tools, are already available. We recommend that universities adopt them rather than developing their own. Certainly, higher education will need to revamp many programs to help faculty acquire new teaching skills that are better suited to technology-intensive classrooms, which, in the future, will be less dominated by lecture and more driven by collaborative projects or online mentoring. But to delegate all training on Web publishing to schools of education might risk duplicating many services already offered by online communities—yet another case of new electronic communities that crisscross the boundaries of traditional higher-education institutions. Higher education must find strategies for coordinating with electronic communities, if only because much of the literature and training they offer is good, and free.

- Shift staff time from teaching to creating courseware. Courses and communities might help faculty acquire skills in Web-based courseware development, but one big question remains: Where will the money come from to pay for the acquisition, to say nothing of the time? We suggest that it can be done at roughly current levels of funding, provided faculty can reallocate the time they devote to their various teaching activities. Since information technology is slowly beginning to displace faculty by performing some of their traditional teaching roles, staff could spend more time creating courseware. If the transition from lecture-intensive curricula to Web-based courseware is managed reasonably, the added course-development time may come at little or no increased cost to higher-education institutions.

- Nourish grassroots publication. Higher-education institutions can also encourage the development of quality Web courseware through tactics that help foster and manage the grassroots, or individual, publishing that we see taking shape in online communities such as the World Lecture Hall. Universities and colleges could follow GNA’s lead, for example, and provide a common infrastructure for online courses. Perhaps they would do
even better to copy proprietary institutions (such as Microsoft’s OnLine Institute), which supply value-added services that establish goals and areas for new courseware, offer technical assistance to courseware developers, and furnish quality-control standards. In addition, setting standards for courseware format (to ensure interoperability) will probably be as important as establishing content standards. Overall, the intent of these tactics must be to foster a culture of sharing in online communities of higher education.

How Will Higher Education Choose Among Many Models for Using the Internet and Web?

Assuming higher education has the financial, physical, and human resources necessary to use the Web and Internet, what structures or models should it adopt to deliver educational services? Perhaps both the biggest blessing and biggest challenge of the Internet is that it makes possible so many alternative models for learning, teaching, and education delivery. We cannot recommend a single model. Rather, we suggest that higher-education institutions examine many possible models, choosing and tailoring those that are most consistent with their missions and financial constraints, and that also take into account the imminent sea changes in the educational market: the growth of new private providers, the increasing diversity of student populations, and the rapid turnover of skills in emerging knowledge-based industries.

We further recommend that higher-education institutions deliberately attempt to consider models that call into question as many features of traditional institutions as possible—for instance, the length of courses, the size of classes, the bundling of now-separable services such as courseware creation, delivery, and student credentialing. Specific questions might include:

- Is it reasonable to consider creating ultra-short courses that can be aggregated by students into highly tailored educational experiences, on an as-needed basis?
- To what extent, and under what conditions is it possible to develop technology-intensive distance-learning courses that offer
open (or at least dramatically increased) student enrollment, while keeping course quality high?

• Should all institutions be developers of educational courseware, or is there a role for value-added course brokers and repackagers?

• More generally, to what extent is it now technically feasible, and economically sensible to unbundle the value-chain of educational services traditionally offered by higher-education institutions—ranging from course-content creation, to reselling, to marketing, to brokering, to distribution?

We recommend these “what if” experiments not necessarily because traditional institutional structures are terribly flawed, but because alternatives resembling familiar models are likely to be explored while less-familiar ones go unnoticed. More than anything else, we hope to initiate discussion of these unusual, and sometimes useful, alternatives.

CONCLUSION

Our analysis suggests many reasons for optimism. However, we do not regard information technologies as an unqualified answer to the problems of higher education. Many of the most effective uses of technologies will not improve productivity in higher education in any simple sense; rather, they will transform the processes and products of learning and teaching. As a result, they may threaten the current structure of the university more than just streamline it. Such transformations will have costs as well as benefits, and the prospect of fundamental structural change will require that policy issues be addressed not only by higher-education institutions but by state and federal governments.