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.

Information technologies have played a vital role in higher education for decades. Television started sending instruction to campuses and homes during the 1950s (remember Sunrise Semester?); before that, radio and film were used in a wide range of courses; and computers have populated labs in schools since the late 1960s. But only recently has interest in educational applications of information technology, which now includes the Internet and the World Wide Web, reached nearly universal proportions. In the past, discussion of educational technology was limited mainly to academic and teaching journals; now, almost every major newspaper has devoted at least a series of articles or a Sunday supplement to “Learning in Cyberspace,” touting technology as a savior for education.
As veterans in the battle to move computers into classrooms, we in the Institute on Education and Training at RAND are naturally excited by this surge of interest. But we are also anxious, because this is not the first time technology has been touted as a savior for education, and all previous technology “revolutions” have failed, in part because they were not, technically, great improvements on prior educational tools. Of course, past failures have not been complete flops; after all, the use of instructional TV and computer-based integrated learning systems, for example, persists in schools and campuses, although mainly on the margin. And newer technologies, from CD-ROM-based multimedia products to Internet chat rooms, are potentially much more powerful than previous technologies; so they should avoid many prior technical limitations. However, like the previous technology revolutions, the impending information-technology revolution also may fall far short of expectations.

With the hope that we can help the revolution move forward, we offer here a critical, constructive review of the potential opportunities that new information technologies afford higher education.

A QUALIFIED VISION

We admit, at the outset, that we believe that information technologies can help higher education reach many of its goals. We will go even further to say that our vision is organized around the pervasive use of interactive and high-bandwidth communication networks. In particular, the model we champion is the Internet, the World Wide Web (WWW), and its generic tools (e.g., browsers such as Netscape), which are used to create and run applications (now often called “homepages”). But it is not the early Web (as late as 1995), with its static book pages rendered electronically, that we think could revolutionize education and learning. It is, instead, the emerging global information infrastructure (GII) of dynamic Web objects that will succeed the current Internet and WWW—a computational environment populated by many multimedia and interactive applications, as well as human and computer agents—which will be the focus of our discussions.

Higher-education institutions, in general, are very well represented on the Internet. This is hardly surprising: For its first 25 years, the Internet (until 1990 called the ARPANET) was inhabited mainly by
universities, nonprofits, and government agencies. True, some colleges and smaller universities still lag behind, but the larger schools remain among the most extensive and most sophisticated users of Internet and Web resources—even today, as commercial sites rapidly take over cyberspace. Put most positively, the Internet is probably the only information-technology arena in which higher education has more than kept pace with the business world, both in its raw capacity and its skill in creating useful products. (On a given day, the average university classroom surely logs more Web-site “hits” than phone calls.)

Of course, many technologies other than the Internet can and do play important roles in education. Stand-alone computers run many kinds of useful instructional programs; they will continue to be important as machines drop in price even as they increase in power. And, today certainly, more educational information is delivered on CD-ROM than through networks such as the Internet. Still, we favor the Internet as a unique foundation for education because it will eventually include all the functionalities of the other available tools, and more. Rooted in relatively primitive network applications that transfer files of text (e.g., ftp), over the past few years, the World Wide Web has added layer upon layer of new communication protocols and document types. Now you can find Web sites that imitate almost all other communication devices and genres—audio or video, two-way or one-way, broadcast or point-to-point. But are these imitations? Perhaps it is better to view the Internet simply as a flexible new medium that can merge or encompass all old (and new) information technologies. A few of the Web sites that are chameleons masquerading as other media are summarized in Figure 1.1. (This list was compiled in May 1997.) While the Internet can mimic more-traditional information media and genres, it also offers novel functionalities not found elsewhere—multi-user video games (such as “Quake”; http://www.idsoftware.com/), interactive soap operas (such as “The Spot”; http://www.thespot.com/), and online “chat” rooms (such as “V-Chat”; http://www.microsoft.com/ie/chat/), for instance.

Some of the Web site URLs given in this document are broken at the ends of text lines, for typographical purposes. However, they should be read as unbroken character strings with no intercharacter spaces.
<table>
<thead>
<tr>
<th>Function</th>
<th>Web Site Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td>NPR’s site (<a href="http://www.npr.org/">http://www.npr.org/</a>) includes many of their programs, current and past, including newscasts updated every hour. Net Radio (<a href="http://www.netradio.net/">http://www.netradio.net/</a>) permits listeners to select different types of music, as well as “talk radio” features, at a click of the mouse. Both NPR and Net Radio use Real Audio (<a href="http://www.realaudio.com/">http://www.realaudio.com/</a>) as a helper application.</td>
</tr>
<tr>
<td>Telephone</td>
<td>VocalTec’s Internet Phone (<a href="http://www.vocaltec.com/">http://www.vocaltec.com/</a>) provides telephone-quality, point-to-point, voice communication over the Internet. Internet Phone incurs no long-distance charges, much to the consternation of traditional long-distance providers.</td>
</tr>
<tr>
<td>Television</td>
<td>Many Web sites are already devoted to commercial TV; most are simply advertising, but several include substantial video. PBS’s “Life on the Internet” (<a href="http://www.pbs.org/internet/">http://www.pbs.org/internet/</a>) was a 13-part video series made available on the Internet. It used VDOLive’s (<a href="http://www.vdolive.com/">http://www.vdolive.com/</a>) Internet video technology and servers. HyperTV (<a href="http://www.hyperv.com/">http://www.hyperv.com/</a>) promises to interweave traditional TV transmission and Internet browsing. MSN (<a href="http://www.msn.com/">http://www.msn.com/</a>) acts more like a TV network than a single TV channel or program.</td>
</tr>
<tr>
<td>Newspaper</td>
<td>Hundreds of newspapers are now online. Some are faithful to their hardcopy versions; others are better designed for the Web. In this regard, The New York Times on the Web (<a href="http://www.nytimes.com/">http://www.nytimes.com/</a>) falls about in the middle.</td>
</tr>
<tr>
<td>Phone book</td>
<td>BigBook (<a href="http://www.bigbook.com/">http://www.bigbook.com/</a>) not only boasts a very complete interactive Yellow Pages for the whole nation, but also will display a map showing the location of a business, as well as reviews offered by other users.</td>
</tr>
<tr>
<td>Billboard</td>
<td>CyberBillboard (<a href="http://village.ios.com/~cyber/cbbdesgn.htm">http://village.ios.com/~cyber/cbbdesgn.htm</a>) will design and post digital billboards on the Web for customers.</td>
</tr>
<tr>
<td>Fax</td>
<td>There are any number of ways to send a fax on the Internet. Try just printing, say, a Word document to a fax “printer.”</td>
</tr>
<tr>
<td>CD-ROM-based video game</td>
<td>As the Internet’s multimedia capacity has expanded, Nintendo (<a href="http://www.nintendo.com/">http://www.nintendo.com/</a>), Sega (<a href="http://www.sega.com/">http://www.sega.com/</a>), and other video game companies that used to distribute products either on CD-ROMs or cartridges have made many new and old titles available on the Web.</td>
</tr>
<tr>
<td>Intelligent tutoring systems</td>
<td>Rebel! is an interactive, exploratory environment for learning history through simulation. It was originally configured as a standalone application, running on a Macintosh; but it was reconfigured to display to, and interact with, users on any machine connected to the Web.</td>
</tr>
</tbody>
</table>

Figure 1.1—The Internet and World Wide Web As Communication Chameleons
Supported by emerging standards such as the Common Object Request Broker Architecture (CORBA), new document formats (now called distributed objects) and communication protocols will evolve into an ever-expanding collection. These will give rise to more and more genres unique to digital networks—products that imitate no previous forms of communication.

If interaction is omitted, the Internet can become instructional TV; if text and other symbolic media are omitted, it can mimic two-way video; if multi-casting is omitted, the Internet might look like a one-on-one intelligent tutoring system; the Internet can even impersonate fax, radio, and newspapers. The ability of the emerging Internet to encompass just about all other information technologies is potentially critical to realizing its value for higher education.

**Qualifications on the Vision: Why the Road to Revolution Might Be Rocky**

In addition to discussing how this potential could be realized in higher education, we insert a recurring theme that provides a sober counterpoint to this promising picture. We claim that information technology—or any profound innovation—leads to a fairly predictable sequence of events as it is adopted in society:

- First, it is exploited as an enhancer, or magnifier. The innovation is used to accomplish traditional practices (in manufacturing, services industries, even education) more efficiently or productively.

- Later, it becomes a transformer. It leads to new practices and products, not simply better versions of traditional ones. This shift is usually very slow and rarely smooth.

Traditional applications of new technologies can lead to improvements that are more valuable than the original version of the technology, so there is often good reason to resist fundamental change. For example, early gas-powered vehicles designed to resemble horseless carriages are useful. But, in the long run, the technology affords new opportunities that can be more valuable: Cars are much more useful. Yet this transformation is not without great uncertainty and great cost—in time, money, and fundamental restructuring.
Cars dominate carriages only if we build paved roads, provide service stations, and pass laws that govern speed and the transport of goods.

This idea is not new (it parallels the economic distinction between process and product innovation, for example) but will arise often in our discussions. We discuss many possible applications of information technologies in higher education. Some relatively traditional applications are attractive in the short term because they can help cut costs. There is certainly no reason to reject them. But innovative applications could help solve other important problems in the long term, even though they may not save money in the short term. The difficulty is that some of these applications are not just technology fixes or add-ons; they will require that the higher-education community think hard about its mission, its organization, and its willingness to invest in change—even in a time of fiscal tightening.

**THE PLAN**

Our discussion begins with examples that illustrate many interesting, cutting-edge applications. But, unlike many discussions of education in cyberspace, our focus is on information technology as a tool to help solve the central problems in higher education. We consider:

- the need to reduce costs and to increase productivity in the face of dwindling resources
- the challenges of an expanding and increasingly diverse student population (including minorities and geographically isolated rural or inner-city populations, as well as lifelong learners who must retool their skills)
- the necessity of adapting to changes in industry and social demands (a broad shift away from manual laborers and toward knowledge workers)
- competition with a growing number of external providers—proprietary, for-profit firms not associated with colleges or universities (often specializing in corporate training but almost always exploiting information technology).

Information technologies can affect many facets of higher education, much as they do almost every service industry. We focus here on the
opportunities that appear unique to education, ignoring many im-
portant applications. For example, we pass over the different ways 
technologies already streamline student-record maintenance, bud-
getting, payroll, and general administration. There is already a large 
body of literature on the costs and benefits to business of computer 
and communication technologies, and educational applications add 
few new insights to this field. Rather, we look at applications of in-
formation technologies from the inner missions of higher education 
outward:

- the benefits for learning and instruction delivery that new infor-
mation technologies can promise
- the ways in which information technologies can help provide 
tools for building instruction
- the tools information technologies can offer for improving deci-
sionmaking and community-building within higher education
- the manner in which information technologies can help connect 
higher-education institutions to industry and society as a whole.

In these discussions we summarize available data on how technology 
helps overcome important challenges to higher education. But we 
also include many sidebars of current or emerging “best practice.” 
Our arguments are illustrated by anecdotes, or examples, partly be-
cause they bring abstract claims to life and partly because there are 
few hard data on what new technologies can really do for higher ed-
ucation.

We next summarize the evidence about these applications to clarify 
those that are less than they seem; uncover others that may be more 
promising, although perhaps less obviously so or less colorful; and 
identify the hidden costs—costs that must be paid if even the most 
promising uses of information technology in higher education are to 
deliver what they suggest. This summary leads to a more complete 
discussion of the barriers to realizing the potentials of new tech-
ologies in higher education and, finally, to some broad policy issues 
that surround the resolution of these problems.