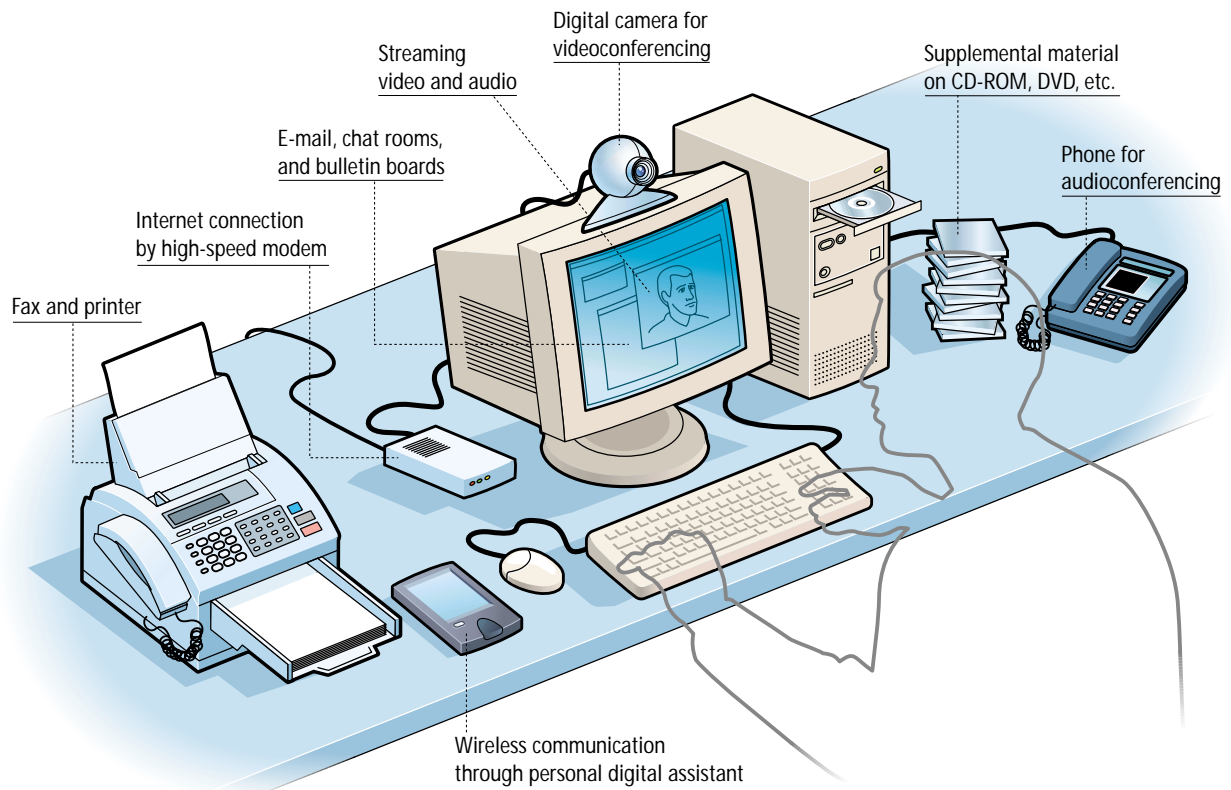


Learning on-line is one of the fastest-moving trends in higher education, as engineers and executives in technology industries are discovering

Engineers turn to e-learning



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[1] Telecommunications and computer technologies are converging to make on-line learning more of an interactive experience. It is estimated that by the year 2005, the typical on-line student will have at his or her disposal all of the gadgets pictured here. Today, though, on-line courses make do with far less.

ILLUSTRATION: STEVEN STANKIEWICZ

“It’s like teaching through a straw,” winced an engineering professor who had just spent 13 weeks interacting through the Web with a dozen graduate students. The members of his class, like more than a million others worldwide who now take courses entirely on-line, downloaded his lecture notes from the Web, communicated with each other and their instructor through e-mail, and took exams by responding to questions on computer screens at home or at work. Even in the absence of face-to-face interactions in the classroom, these students found that the convenience of Web education made learning through a straw very sweet.

Since before the days of Socrates, teaching has largely involved flesh-and-blood instructors lecturing to their students—beneath a tree, in a colonnaded stoa, or in a brick-and-mortar schoolroom. Today, though, thanks to widespread access to the Internet, on-line education is enabling professionals to learn from afar, keeping pace with technological and managerial changes despite their heavy schedules.

E-learning, especially for engineers and executives in technology industries, has emerged as one of the fastest-moving trends in higher education. Thousands of technical and management courses, including degree and certificate programs, are now being offered by universities, for-profit professional development centers, and industry training facilities worldwide. Among the biggest of these is the University of Maryland's University College in Adelphi, which boasts an on-line student body of more than 30 000.

To be sure, the ability to instruct from afar is hardly new. As early as the mid-1800s, correspondence schools in Europe were teaching shorthand and foreign languages by mail. In the last century, radio, television, and satellite broadcasting equipped distance learning with new methods of delivery. The global connectivity of the Internet and a new generation of hardware and software applications underpin the teaching of courses over the Web [Fig. 1].

By almost any measure, e-learning is booming. According to a recent U.S. government report, the demand for e-learning is likely to leap from just 5 percent of all students in higher education in 1998 to 15 percent by 2002. In the corporate sector, spending on employee training last year totaled \$2.5 billion, about 40 percent of which went to on-line education. What's more, industry e-training is projected to double annually over the next several years. The academic on-line market is also expected to move ahead rapidly, reaching nearly \$1.6 billion by 2002. What many educators are realizing is that e-learning is a trend they can no longer ignore.

THE ENGINEER AS E-LEARNER

As any working engineer knows, there is tremendous pressure to keep pace with the latest technology and the newest ways of doing business. "Engineers tell me that they need a thorough refresher course in their specialties at least every other year," *IEEE Spectrum* was told by Peter F. Drucker, the best-selling author and management guru. "And a 're-immersion'—their word—in the basics at least every four years."

Yet few engineers have the luxury of attending classes on well-groomed college campuses. Even those who do enroll in graduate school often attend part-time in the evenings, rushing off to class after work, grabbing a bite to eat along the way. When

1. A sampling of on-line engineering courses offered

School	Courses or programs
University of California, Berkeley http://explore.berkeley.edu/	<ul style="list-style-type: none"> • Computer information systems • Digital telecommunications, • E-commerce • Geographic information systems
Drexel University, Philadelphia http://online.drexel.edu	<ul style="list-style-type: none"> • Competitive intelligence • Engineering management • Information systems
Fairleigh Dickinson University, Madison, N.J. http://www.fdu.edu/webresources/webcampus.html	<ul style="list-style-type: none"> • Computer networks • Electrical engineering
Franklin University, Columbus, Ohio http://online.franklin.edu	<ul style="list-style-type: none"> • Computer science • Management information systems
Georgia Institute of Technology, Atlanta http://www.conted.gatech.edu	<ul style="list-style-type: none"> • Digital signal processing • Mechanical engineering
University of Hawaii, Manoa http://www.hawaii.edu/dl/	<ul style="list-style-type: none"> • Computer and information sciences • Telecommunications
University of Illinois Online, Urbana http://www.online.uillinois.edu	<ul style="list-style-type: none"> • Expert systems • Microelectronics processing • Power electronics • Reliability engineering
Kansas State University, Manhattan http://www.dce.ksu.edu	<ul style="list-style-type: none"> • Software engineering
University of Maryland University College, Adelphi http://www.umuc.edu	<ul style="list-style-type: none"> • Computer systems management • Environmental management • Software engineering • Telecommunications management
University of Massachusetts, Lowell http://continuinged.uml.edu/	<ul style="list-style-type: none"> • Information systems • Intranet development • Unix

SOURCE: American Society for Engineering Education, Alfred P. Sloan Foundation, and individual Web sites. Includes only programs taught exclusively on-line.

the bell rings at the end of class, they are soon back in the parking lot, speeding off for home. For these part-time learners—the lion's share of today's graduate population—the actual classroom can be far more alienating than the virtual one.

"Traffic and parking are two of my biggest hassles," said Dean C. Reonieri Jr., a software developer at Lucent Technologies Inc. who has been taking graduate courses through the Web from Stevens Institute of Technology, in Hoboken, N.J. "The best thing about taking an on-line course for me is convenience."

Gautham Natarajan, who works in net-

work planning at AT&T Corp. in New Jersey, agrees. He enrolled in two on-line telecommunications courses offered by Stevens Institute last spring, and found it "very flexible. I could access the courses whenever I wanted—at home, at work, wherever there was a computer nearby." Natarajan estimates that he saved 45 minutes in commuting each way.

The business world is also finding on-line learning to be a boon for employee training, especially as more corporations become global enterprises. One corporate training executive recalled that, not long ago, his mission was to provide classes for engineers

by U.S. universities

School	Courses or programs
Michigan State University, East Lansing http://www.vu.msu.edu	<ul style="list-style-type: none"> • Global engineering education • Telecommunications • Computer-aided design
New Jersey Institute of Technology, Newark http://www.njit.edu/DL/	<ul style="list-style-type: none"> • Computer network design • Software development • Telecommunications management • Web development
New York University, New York City	<ul style="list-style-type: none"> • Internet/Web technologies • Multimedia technologies • Networking • Programming
Northern Virginia Community College, Annandale http://eli.nv.cc.va.us/vc/	<ul style="list-style-type: none"> • Information systems technology
Pace University, New York City http://online.pace.edu/	<ul style="list-style-type: none"> • Computer science and information systems
Pennsylvania State University, University Park http://www.worldcampus.psu.edu	<ul style="list-style-type: none"> • Geographic information systems • Management info. systems • Noise control engineering • Reliability engineering
University of Southern California, Los Angeles http://den.usc.edu	<ul style="list-style-type: none"> • Aerospace engineering • Computer science • Electrical engineering • Industrial and systems engineering
Stanford University, California http://scpd.stanford.edu	<ul style="list-style-type: none"> • Artificial intelligence • Computational molecular biology • Optical-fiber communications • Wireless communications
Stevens Institute of Technology, Hoboken, N.J. http://www.webcampus.stevens.edu	<ul style="list-style-type: none"> • Computer science • Technology management • Telecommunications management • Wireless communications
University of Wisconsin, Madison http://www.uwex.edu	<ul style="list-style-type: none"> • Engineering economics

in two or three sites in New Jersey. These days he is responsible for training employees in several countries in Europe, Asia, Australia, and Latin America.

Some firms now operate “corporate universities” on-line—two examples are Dell Learning, for workers at Dell Computer Corp., Round Rock, Texas, and SunU, run by Sun Microsystems Inc., Palo Alto, Calif. Many of these corporate sites collaborate with academic institutions to either deliver courses straight out of the school catalog or produce customized courses. For-profit Web sites are also popping up to fill the technical training niche, offering product-specific

courses in such topics as Linux, Microsoft Windows NT and 2000, and Novell Netware.

THE VIRTUAL CLASSROOM

Just as in conventional classrooms, the day-to-day activities of on-line education vary widely. College and university e-courses tend to follow the standard academic calendar, lasting from 12 to 15 weeks. The instructor indicates at the start of the term what is required—whether and when students will take midterm or final exams and submit problem sets or final projects—and how the course will be conducted.

Typically, each course has its own home-

page on the Web, where the instructor posts class materials, such as lecture notes, homework problems, reading assignments, and video clips of lectures or demonstrations. Pedagogically, the Web’s archival ability is one of its great advantages over the classroom. In particular, it enables “asynchronous” learning: students can access the course Web site whenever and wherever convenient—at home before work, during lunch breaks at the office, or in the middle of the night. In some cases, though, students may need to log in at designated times for live Webcasts of lectures or for chat sessions with classmates. Some courses also stipulate that students show up on campus for an initial meeting with the instructor and other students.

With many e-learning courses, though, the class never meets in person. Instead, they communicate on-line—not just to hand in homework, but also to ask questions, comment on class topics, and respond to comments and questions from others. The instructor may even break the class up into groups, to work on team projects or reports. That fosters what educators call “collaborative learning,” an interactive style of problem-solving that in many cases improves students’ understanding.

“Without some kind of discussion, distance learning is pretty worthless,” observed Howard R. Budin, head of the Center for Technology and School Change at Teachers College in New York City. Like many e-teachers, Budin weights students’ grades by their degree of participation in on-line discussions. For the most part, though, e-learners’ grades are still determined largely by how they do on exams and homework.

E-LEARNING TECHNOLOGY

From the student’s perspective, the mechanics of on-line learning are as simple as logging on to the Internet. To run most e-learning software, the student will need a Pentium-class PC with the latest version of Windows, or else a recent-issue Macintosh. The machine should have sufficient random access memory (32MB or more) and a modem that operates at 56 kb/s or higher. Also essential is an account with an Internet service provider (ISP) that includes e-mail and access to the World Wide Web.

Students typically submit homework and sometimes exams as e-mail attachments, so they need e-mail software that handles attachments and a current version of a word-processing program like Microsoft Word or WordPerfect. As for Web browsers, the latest version of Netscape Navigator or Microsoft Internet Explorer is usually recommended. Other programs that may be required include Adobe Acrobat Reader, Windows Media Player, and RealPlayer.

The market in on-line learning has

matured to the point where there is now decent software for designing, teaching, and administering a Web-based course [see "Popular e-learning software packages," below]. These vary in both technical sophistication and intended audience. Basic features include a user interface for uploading and downloading course material; sending and receiving e-mail; and giving and grading of e-exams. Many platforms also accommodate threaded discussion lists, chat rooms, bulletin boards, and file sharing. Some allow streaming video and audio—for lectures and the like—although downloading such files may pose a problem for those without a high-speed broadband connection to the Internet. Some platforms let the instructor monitor what each student reads on-line for the class.

Typically, an organization will use one e-learning platform for all its courses. Loading the software onto a network server is no harder than introducing other soft-

ware. Stevens, for instance, uses WebCT running on an Apache version 1.3.9 Web server. In corporate environments, firewalls may block unsecured Web traffic from intruding into company systems; in that case, the software can be mounted on a local-area network or intranet, or on a server that resides outside the firewall.

Many instructors need help setting up their courses. Accordingly, organizations are engaging "instructional designers," whose job description lies somewhere between technical support and education. Before a course goes on-line, they work with the instructor to create the structure for it. Once the course is under way, they help upload course material to the server and field questions about using the e-learning software.

Uploading course material is not complicated. Suppose the material was created in Word. First, one saves it as a hypertext markup language (HTML) file; the file is then uploaded to a designated slot on the server, in line with instructions for the e-learning software. Non-text files, like streaming video and applets, are uploaded in the same way, into a file database, with each item hyperlinked to a location the instructor designates—a lecture area in Week 1, say, or a file of readings.

NO SIGNIFICANT DIFFERENCE

Do students learn as well on-line as they do on campus? Yes, according to the scholarly literature to date. In a widely cited report summarizing the results of such studies, Thomas L. Russell, director emeritus of instructional telecommunications at North Carolina State University, at Raleigh, wrote, "The good news is that these 'no significant difference' studies provide substantial evidence that technology does not denigrate instruction."

At Stevens, instructor Hosein Fallah tested that statement by teaching his course on U.S. telecommunications policy both conventionally and on the Web. To eliminate any bias, Fallah graded the mid-term exams without knowing which of the classes they came from. As the literature predicted, the grades in both classes were practically the same.

Naturally, not every student will find on-line learning to his or her liking. For one thing, it may require more discipline and maturity than conventional education.

Nor do all instructors take to e-learning. A common criticism was articulated in the recent best-

seller *The Social Life of Information* (Harvard Business School Press, 2000) by Xerox Corp. chief scientist John Seely Brown and University of California at Berkeley historian Paul Duguid. They argue that many schools are rushing to compete with for-profit companies by offering inexpensive "unplug and pay" courses. While on-line learning may add some value to an education, the authors state, they cannot replace life on a real campus. Through the experience of attending class and meeting informally with peers and teachers, students gain more than mere information. They learn "distinct ways of judging what is interesting, valid, significant."

Then, too, there are logistical questions raised by on-line learning. For the college professor, a chief concern is how much extra time will be consumed by producing and teaching a Web-based course. Most academics feel their days are already full enough, what with classroom teaching, research, meetings, and other duties. For them, the most troubling thought may be that they will have to devote long hours responding to e-mail from students.

Some on-line instructors do find that the total time can far exceed a traditional course's classroom sessions and office hours. Loretta Donovan, head of the distance learning program at Mercy College, Dobbs Ferry, N.Y., estimated that she devotes about 20 to 30 minutes per week per on-line student. Donovan once got 160 messages in two days from her students. "I'm very good at scanning," she told *Spectrum*. That extra time is worth spending, Donovan said, because on-line courses offer a "much richer experience" than conventional classroom instruction.

And not all instructors find Web teaching more time-consuming. Hosein Fallah figures he works the same amount on his conventional and on-line classes, but the time "is distributed differently. Instead of being tied to a concentrated period of classroom teaching and office hours, you're on-line every day." And, because Fallah also supplements his traditional courses with Web materials, he said, "I now get lots of e-mail from my in-class students, too." That trend is seen elsewhere in higher education. Beginning this semester at Georgia Tech, for example, all on-campus undergraduate courses in electrical and computer engineering will include some e-learning components.

Indeed, e-learning's most profound effect is on campus, claimed Edward Borbely, head of the Center for Professional Development at the University of Michigan's College of Engineering. While engineering instruction has traditionally involved "writing on the board," with little interaction among students, he said, "now professors are using Web sites as classroom tools." Because the Web forces teachers to rethink their courses,

Popular e-learning software packages

Several commercially available software tools make it easier to design, run, and manage on-line courses. Although most require a little knowledge of hypertext markup language, not much programming or other technical expertise is needed.

Typically, e-learning platforms permit students to log on securely using a standard browser. In most cases, they include a database-centered syllabus with links to internal or external Web pages; on-line, time-monitored testing; discussion groups; and e-mail.

Among the most popular e-learning packages:

- Blackboard's CourseInfo (<http://www.blackboard.com>) is an on-line course management system that uses templates.
- Lotus LearningSpace (<http://www.lotus.com/home.nsf/welcome/learnspace>) is primarily targeted at corporate users. It is sold through IBM Corp.'s recently formed e-learning business unit, IBM Mindspan Solutions.
- WebCT (<http://www.webct.com>) is a low-cost, asynchronous course delivery and management system developed at the University of British Columbia, Vancouver, B.C., Canada, and now sold through Universal Learning Technology, Peabody, Mass.
- Topclass by WBT Systems, Waltham, Mass. (<http://www.wbtsystems.com>), is the most mature product on the market.

In addition to the above, a number of vendors offer customized e-learning platforms for colleges and training organizations. These include DigitalThink (<http://www.digitalthink.com>), Convene (<http://www.convene.com>), and eCollege (<http://www.ecollege.com>).

—R.U.

many come away saying that their on-campus style has improved, Borbely said.

To wean instructors from their dependency on classroom lecturing, Stevens Institute introduced Web Faculty Colloquia. This program gives those new to on-line instruction a chance to demonstrate their digital accomplishments and discuss their uneasiness about virtual pedagogy. New e-teachers also receive intensive training in Web software. So far, the results have been quite positive, with some previously reluctant professors emerging as e-learning enthusiasts.

FOOTING THE E-LEARNING BILL

While the introduction of e-learning may not require breaking ground for new buildings, mounting an e-learning site is "certainly not free," observed Georgia Tech vice provost Joseph DiGregorio. "We're constantly scraping for funds to launch new programs."

Faculty compensation is perhaps the biggest cost. DiGregorio estimated that a third of Georgia Tech's on-line learning budget goes to salaries. At Stevens, Web faculty receive two fees, one for developing their e-course, another for teaching it over the Internet. Additional administrative and technical staff are also needed to run Web learning programs, which, unlike traditional classrooms, must be kept up and running around the clock.

Add to that the costs of training, software licenses, e-commerce applications, Web design tools, upkeep of computer and telecommunications infrastructure, and the bill for venturing into virtual space quickly balloons. Some institutions that have launched major e-learning ventures, among them Pennsylvania State University's World Campus and the State University of New York's Learning Network, have spent many millions of dollars on infrastructure and staff.

For the student, tuitions for Web-based courses are comparable to those for conventional classes. Whatever time and effort the student may save in avoiding the commute to campus must be balanced against the cost of computer hardware and software and Internet service to access the course on-line.

Still unanswered at most schools is the question of intellectual property. Who owns e-learning courses? The professors who designed them? The school? Both? Although some universities have adopted policies that appear to settle the matter amicably, it is emerging elsewhere as one of the most contentious battles on campus.

THE E-LEARNING CATALOG

Quite probably certain types of instruction will never go entirely on-line, like laboratory courses that require access to expensive, specialized equipment. That said, a wide assortment of technical topics can be

taught through the Web [see "A sampling of on-line engineering courses offered by U.S. universities," p. 60].

Stanford University, in California, was one of the first schools to provide instruction over the Web, and it now offers, through its Center for Professional Development, more than 250 technical and management courses to some 5000 working professionals. Students can earn master's degrees or take short courses in a number of engineering fields.

This year, Stevens introduced six on-line graduate programs, known collectively as WebCampus.Stevens. (The school continues to offer distance-learning programs at corporate sites using interactive video.) Recently, the school teamed up with the IEEE (*Spectrum's* publisher) to co-sponsor graduate-level courses aimed at "engineers in industry who need applications-oriented skill upgrades useful for their jobs and careers," explained Peter Wiesner, the IEEE's director of continuing education. Under the terms of the partnership, IEEE members receive 10 percent reduction in tuition. The IEEE is pursuing similar arrangements with the New Jersey Institute of Technology, Pace University, and U.S. Open University.

One of the more rigorous e-learning graduate programs is the master of engineering in professional practice (MEPP) at the University of Wisconsin—Madison. Under development for six years, it is a part-time, two-year program designed for working engineers. Students have enrolled from Maine to California and Florida to Washington and from several of the nation's top companies—Boeing, General Electric, Motorola. Except for a week of orientation on campus at the start of each academic year, all the courses are delivered over the Web. Among the program's more innovative offerings is a course on "Creating and Maintaining the Virtual Engineering Office."

According to MEPP director Wayne P. Pferdehirt, it is critical to monitor students' progress. On-line counselors help applicants register and apply for financial aid. If the school has not heard from a student in a few days, the counselor will track him or her down. Often such a student's silence turns out to mean that he or she is traveling on business.

AN EDUCATIONAL SMORGASBORD

In the coming years, technological advances, such as wireless networking, will undoubtedly help make e-learning more attractive. And as high-speed, broadband Internet connections become the norm, more real-time, interactive uses of the Web will appear in on-learning classes. That in turn may enhance the sense of community among geographically scattered learners.

Because of the way people work today and because of new lifestyle trends, not to

mention data showing that full-time, on-campus education occupies a much slimmer slice of the educational terrain, many colleges and universities believe that introducing alternatives to conventional teaching is a matter of their survival as educational institutions. Not that traditional classrooms will go away entirely. More likely, e-learning will take its place alongside a range of options—an educational smorgasbord—from which the student will be able to pick exactly the right course at the right time and place. ♦

TO PROBE FURTHER

The American Society for Engineering Education's Continuing Education and Distance Learning Catalog is available on the Web at <http://www.learnon.org>. It lists approximately 3000 courses, giving school, course titles, and mode of delivery, among other attributes. Other sources are *Peterson's Guide to Distance Learning Programs* and the Princeton Review's *The Best Distance Learning Graduate Schools*.

For a comprehensive guide to distance learning listserves, software, training, collaborative environments, and Web course development tools, see the Web Based Learning Resource Library, hosted by Robert H. Jackson, at <http://www.outreach.utk.edu/weblearning>.

Data on academic distance learning in the United States appear in the National Center for Education Statistics report, "Distance Education at Postsecondary Education Institutions: 1997-98," by Laurie Lewis, *et al.* (U.S. Department of Education, Office of Educational Research and Development, Washington, D.C., 1999). The report is on-line at <http://nces.ed.gov/pubs2000/2000013.pdf>.

Thomas L. Russell's report "The No Significant Difference Phenomenon" (North Carolina State University, 1999) concludes that students perform about the same in on-line courses and traditional classrooms.

Publications that cover distance education extensively include the *Journal of Asynchronous Learning Networks*, at <http://www.aln.org/alnweb/journal/jaln.htm>, and *American Journal of Distance Education*, <http://www.ed.psu.edu/ACSDE/ajdel/jour.asp>. Other good sources are the *Chronicle of Higher Education* and the magazines *Converge* and *Educause Quarterly*.

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