It is clear that educational technology is essentially the product of a great historical stream consisting of trial and error, long practice and imitation, and sporadic manifestations of unusual individual creativity and persuasion.

Anna was almost as proud of her new classroom computers as she was of her new teaching degree. She had high hopes for the 1978–1979 school year in her first teaching position, especially since the principal had asked her if she could use two brand new Apple computer systems that had been donated to the school. As a student teacher, she had helped children use computer-assisted instruction (CAI) on terminals that were located in the school's computer lab and connected by telephone lines to her university's big mainframe computer, but this would be much different. Now the computers would be located right in her own classroom, and how she used them would be completely up to her. With her new skills and these marvelous devices at her disposal, she felt a heady sense of power and anticipation.

She found some free and “shareware” drill-and-practice and instructional game software packages, and successfully lobbied the principal to buy others. She planned to buy more with money she would raise from bake sales. All the students wanted to use the computers, but with only two machines, Anna quickly devised activities that allowed everyone to have a turn. She had “relay-race math practices” to help them prepare for tests, and she created a computer workstation where students could play math games as a reward for completing other activities and where she could send students in pairs to practice basic skills.

As Anna used her new computers, she coped with a variety of technical problems. Some of the software was designed for an earlier version of the Apple operating system, and each disk required a format adjustment every time it was used. Programs would stall when students entered something the programmers had not anticipated; students either had to adjust the code or restart the programs. Despite these and other difficulties, by the end of the year Anna was still enthusiastic about her hopes, plans, and expectations. She felt she had seen a glimpse of a time when computers would be an integral part of everyday teaching activities. She planned to be ready for the future.

As she prepared to begin another school year, Anna found it difficult to believe it had been almost 30 years since that first pioneering work with her Apple microcomputers. When she moved to a new school building in 2000, each classroom had a five-computer workstation connected to the school network. Teachers downloaded software and media from the school server, and dozens of titles were available across content areas. Her students used the Internet to do research projects and collaborate with students in other locations. Her classroom favorite activity this year was working with students around the state to gather data on prices for various products and services, but they also liked the spreadsheet software’s “Buy a Car” activity.

She also marveled at how many other teachers in the school were using technology now. Everyone communicated via e-mail, and many, like herself, had their own web pages so students and parents could check homework assignments and view class projects. In other classes, students were using graphing calculators and handheld computers to solve problems, and she often heard them talking about the simulations they were doing in science and social studies. A video project to interview war veterans had drawn a lot of local attention, and the student projects displayed on school bulletin boards were ablaze with screen captures from websites and images students had taken with digital cameras.

There were still problems, of course. Computer viruses sometimes shut down the school server, and there was a growing issue with students plagiarizing work from Internet sources. The firewall that the district had put in place to prevent students from accessing undesirable Internet sites also prevented access to many other, perfectly good sites. Some teachers complained that they had no time for the technology-based group projects students loved because they were too busy preparing them for the new state and national tests.

Yet despite these concerns, Anna was amazed at how far they had come from those first, hesitant steps with technol-
ogy in the classroom, and how much more there was to try. She knew other teachers her age who were retiring, but she was too interested in what she was doing to think about that. She had been asked to help design a virtual course for home-bound students. Not a day went by that a teacher didn’t come to her for help on a new Internet page or video project. She couldn’t wait to see what challenges lay ahead. She looked forward to the future.

**OBJECTIVES**

After reading this chapter and completing the learning activities for it, you should be able to:

1. Describe four different views on how to define the term *educational technology*, and identify professional associations that represent each view.

2. Identify periods in the history of educational computing and describe what we have learned from past applications and decisions.

3. Generate a personal rationale for using technology in education based on findings from research and practice.

4. Place a given educational technology resource in one of the following general hardware (stand-alone computer, network, and related device/system) or software (instructional, productivity, or administrative) categories.

5. Identify which one of the following technology resource configurations would be appropriate for a given educational need: laboratories, mobile workstations, mobile PCs (e.g., laptops or handheld computers), classroom workstations, and/or single classroom PCs.

6. Identify the general categories of educational technology instructional/productivity resources: instructional software, software tool, multimedia, distance learning, or a virtual reality environment.

7. Explain the impact of each of the following types of issues on current uses of technology in education: societal, educational, cultural/equity, and legal/ethical.

8. Identify trends in emerging technologies and implications they may have for teaching and learning.

9. Identify technology skills teachers and their students need to have to be prepared for future learning and work tasks.

**KEY TERMS**

- artificial intelligence
- Center for Applied Research in Educational Technology (CARET)
- Digital Divide
- educational technology
- electronic portfolio
- firewall
- global positioning system (GPS)
- hacker
- handheld computer
- hardware
- instructional technology
- laptop computer
- National Educational Technology Standards (NETS)
- No Child Left Behind (NCLB) Act
- radio-frequency identification (RFID)
- software
- software piracy
- tablet PC
- technology education
- virtual reality (VR)
- virtual system
- virus
- virus protection software
- wireless connectivity

For more information on Key Terms, go to the Key Terms module for this chapter of the Companion Website at [http://www.prenhall.com/roblyer](http://www.prenhall.com/roblyer).

---

**INTRODUCTION: WHY DO WE NEED THE “BIG PICTURE”?**

When a classroom teacher like Anna browses the Internet for new teaching materials or has students use handheld computers to take notes, that teacher is using some of the latest and best of what is commonly called *technology in education* or *educational technology*. But, as Saettler (1990) noted in this chapter’s opening quote, educational technology is not new at all, and it is by no means limited to the use of equipment, let alone computer equipment. Modern tools and techniques are simply the latest developments in a field that some believe is as old as education itself.
This chapter explores the link between the early applications of educational technology and those of today and tomorrow. This review serves an important purpose. It helps new learners develop mental pictures of the field, what Ausubel (1968) might call cognitive frameworks, through which to view all applications and consider best courses of action. Several kinds of information help form this framework:

- **Key terminology** — Talking about a topic requires knowing the vocabulary. Yet the term educational technology and many related terms are not defined the same way by everyone. Educators who want to study the field must realize that language used to describe technology reflects differing views by various groups on appropriate uses of educational technology.

- **Reflecting on the past** — Showing where the field began helps us understand where it is headed and why. Reviewing changes in goals and methods in the field over time provides a foundation on which to build even more successful and useful structures to respond to the challenges of modern education.

- **Considering the present** — The current role of educational technology is shaped primarily by two kinds of factors: available technology resources and our perspectives on how to make use of them. Available technologies dictate what is possible, while a combination of social, instructional, cultural, and legal issues influence the directions we choose to take.

- **Looking ahead to the future** — Technology resources and societal conditions change so rapidly that today’s choices are always influenced as much by emerging trends as by current conditions. To be informed citizens of an Information Society, teachers must be futurists.

**What Is “Educational Technology”?**

**Origins and Definitions of Key Terms**

References to educational technology and instructional technology pervade professional journals and magazines throughout education. Yet no single, acceptable definition for these terms serves the field, and there is uncertainty even about the origins of the terms. Educational technology historian Paul Saetler (1990) says that the earliest reference for educational technology seems to have been made by radio instruction pioneer W. W. Charters in 1948, and instructional technology was first used by audiovisual expert James Finn in 1963. Even in those early days, definitions for these terms focused on more than just devices and materials. Saetler notes that a 1970 Commission on Instructional Technology defined it as both “the media born of the communication revolution which can be used for instructional purposes …” (p. 6) and “a systematic way of designing, carrying out, and evaluating the total process of learning and teaching…” (p. 6).

While today’s educators tend to think of educational or instructional technology as equipment—particularly electronic equipment—Saetler (1990) reminds us that such a limited definition would have to change over time as resources change. Only about 20 years ago, Cuban’s history of technology in education since 1920 (1986) placed the emphasis on radio and television, with computers as an afterthought. If such a description were written now, the focus might be on the Internet, while 20 years from now it might be on intelligent computer-assisted instruction or virtual reality or whatever these technologies are called then. As the 1970 commission concluded, a broader definition of educational technology that encompasses both tools and processes “belongs to the future” (Saetler, 1990, p. 6).

Therefore, in the view of most writers, researchers, and practitioners in the field, useful definitions of educational technology must focus on the process of applying tools for educational purposes as well as the tools and materials used. As Muffoletto (1994) puts it, “Technology … is not a collection of machines and devices, but a way of acting” (p. 25).

**Four Perspectives That Define Educational Technology: Media, Instructional Systems, Vocational Training, and Computer Systems**

If educational technology is viewed as both processes and tools, it is important to begin by examining four different historical perspectives on these processes and tools, all of which have helped shape current practices in the field. These influences come to us from four groups of education professionals. Because each of these groups emerged from a different area of education and/or society, each has a unique outlook on what “educational technology” is, and each defines it in a slightly different way. To some degree, these views have merged over time, but each retains a focus that tends to shape the integration practices it considers important. These four views and the professional organizations that represent them are summarized in Figure 1.1.

- **Perspective #1: Educational technology as media and audiovisual communications** — This perspective grew out of the audiovisual (AV) movement in the 1930s when higher education instructors proposed that media such as slides and films delivered information in more concrete, and therefore more effective, ways than through lectures and books. This movement produced audiovisual communications or the “branch of educational theory and practice concerned primarily with the design and use of messages that control the learning process” (Saetler, 1990, p. 9). The view of educational technology as media to deliver information continues to dominate areas of education and the communic—
Figure 1.1 Four Perspectives That Shaped Educational Technology

<table>
<thead>
<tr>
<th>Perspectives: Educational Technology as ...</th>
<th>Organization and Members</th>
<th>Historical View</th>
<th>Current View</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1: Media and AV communications</td>
<td>Association for Educational Communications and Technology (AECT) <a href="http://www.aect.org">http://www.aect.org</a> Serves library-media educators</td>
<td>Began with focus on delivering information as alternatives to lectures and books, using devices to carry messages (e.g., films, TV) during instruction. Later added an emphasis on online and computer/information systems as &quot;media.&quot;</td>
<td>Still focuses on technologies as media. Most AECT divisions still focus on concerns of library-media educators; AECT state affiliates usually refer to themselves as &quot;media associations.&quot;</td>
</tr>
<tr>
<td>#2: Instructional systems and instructional design</td>
<td>International Society for Performance Improvement (ISPI) <a href="http://www.ispi.org">http://www.ispi.org</a> Serves higher education and industry instructional designers, trainers</td>
<td>Originally National Society for Programmed Instruction. Emphasized making instruction and training more efficient.</td>
<td>Focus is on creating and validating instructional systems to improve productivity and competence in the workplace.</td>
</tr>
<tr>
<td>#3: Vocational training (a.k.a. technology education)</td>
<td>International Technology Education Association (ITEA) <a href="http://www.iteawww.org">http://www.iteawww.org</a> Serves technology education teachers</td>
<td>Until the 1980s was the American Industrial Arts Association. Focused on skills with manufacturing, printing, woodworking, and metals.</td>
<td>Now focuses on technology-related careers and promoting technological literacy through hands-on experiences that use technology in the context of learning mathematics, science, humanities, and engineering concepts.</td>
</tr>
<tr>
<td>#4: Computer systems (a.k.a. educational/instructional computing)</td>
<td>International Society for Technology in Education (ISTE) <a href="http://www.iste.org">http://www.iste.org</a> Serves technology-using teachers, administrators, and higher education personnel</td>
<td>Until the 1980s, was the International Council for Computers in Education (ICCE). Focused on computer systems to support and deliver instruction.</td>
<td>Merged with the International Association for Computers in Education (IACE; formerly the Association for Educational Data Systems, or AEDS). Advances uses of technology in K–12 education and teacher education and technology skill standards for teachers and students.</td>
</tr>
</tbody>
</table>

...tions industry. As late as 1986, the National Task Force on Educational Technology equated educational technology with media, treating computers simply as another medium (Saettler, 1990).

- Perspective #2: Educational technology as instructional systems and instructional design — This view originated with post–World War II military and industrial trainers who were faced with the problem of preparing large numbers of personnel quickly. Based on efficiency studies and learning theories from educational psychology, they advocated using more planned, systematic approaches to developing uniform, effective materials and training procedures. Their view was based on the belief that both human (teachers) and nonhuman (media) resources could be parts of an efficient
system for addressing any instructional need. Therefore, they equated “educational technology” with “educational problem solutions.” As these training personnel began to work with both university research and development projects and K–12 schools, they also influenced practices in both of these areas. Behaviorist theories initially dominated and cognitive theories later gained precedence. In the 1990s, popular learning theories criticized systems approaches as too rigid to foster some kinds of learning, particularly higher order ones. Thus, the current view of educational technology as instructional systems is continually evolving. (See Chapter 2 for more information on two approaches to educational technology as instructional systems and how each influences methods of integration.)

**Perspective #3: Educational technology as vocational training** — Also known as technology education, this perspective originated with industry trainers and vocational educators in the 1980s. They believed (1) that an important function of school learning is to prepare students for the world of work in which they will use technology, and (2) that vocational training can be a practical means of teaching all content areas such as math, science, and language. This view brought about a major paradigm shift in vocational training in K–12 schools from industrial arts curricula centered in woodworking/metals and graphics/printing shops to technology education courses taught in labs equipped with high-technology stations such as desktop publishing, computer-assisted design (CAD), and robotics systems.

**Perspective #4: Educational technology as computer systems (a.k.a. educational computing and instructional computing)** — This view began in the 1950s with the advent of computers and gained momentum when they began to be used instructionally in the 1960s. As computers began to transform business and industry practices, both trainers and teachers began to see that computers also had the potential to aid instruction. From the time computers came into classrooms in the 1960s until about 1990, this perspective was known as educational computing and encompassed both instructional and administrative support applications. At first, programmers and systems analysts created all applications. But by the 1970s, many of the same educators involved with media, AV communications, and instructional systems also were researching and developing computer applications. By the 1990s, educators began to see computers as part of a combination of technology resources, including media, instructional systems, and computer-based support systems. At that point, educational computing became known as educational technology.

### How This Textbook Defines Technology in Education

Each of these four perspectives on technology in education has contributed to the current body of knowledge about processes and tools to address educational needs. But, as Saetler (1990) points out, no single paradigm that attempts to describe educational technology can characterize satisfactorily what is happening with technology in education today and what will happen in the future. Furthermore, all of the organizations described here seem to be engaged in a struggle to claim the high-profile term educational technology. However, their often-conflicting views of the role of technology in education confuse newcomers to the field and make it difficult for them to learn the role of technology; the resources and issues differ depending on whose descriptions teachers hear and which publications they read. This textbook attempts to address the disparate views on this topic in the following ways:

- **Processes** — For the processes, or instructional procedures for applying tools, we look to (1) learning theories based on the sciences of human behavior and (2) applications of technology that help prepare students for future jobs by teaching them skills in using current tools as well as skills in “learning to learn” for tools of the future that have not yet been invented—or even imagined.

- **Tools** — Although this textbook looks at technology tools as an overlapping combination of media, instructional systems, and computer-based support systems, it emphasizes a subset of all of these resources, focusing primarily on computers and their roles in instructional systems. There are three reasons for this focus:
  1. **Capabilities** Computers as media are more complex and more capable than other media such as films or overheads and require more technical knowledge to operate.
  2. **Convergence** Computer systems are currently moving toward subsuming many other media within their own resources. For example, CD-ROMs and DVDs now store images that once were shown on filmstrips, slides, and videotape. Presentation software (e.g., PowerPoint) has largely replaced overhead transparencies.
  3. **Complexity** Computer-based materials such as software lessons and computer-driven media traditionally have been more complicated for educators to integrate into other classroom activities. Educators can see much more easily—some would say even intuitively—how to integrate less technical media such as films or overheads.
It is with this rationale in mind that this text assigns the following "evolving" definitions:

**Educational technology** is a combination of the processes and tools involved in addressing educational needs and problems, with an emphasis on applying the most current tools: computers and other electronic technologies.

**Integrating educational technology** refers to the process of determining which electronic tools and which methods for implementing them are appropriate responses to given classroom situations and problems.

**Instructional technology** is the subset of educational technology that deals directly with teaching and learning applications (as opposed to educational administrative applications).

---

**Looking Back: How Has the Past Influenced Today’s Educational Technology?**

**A Brief History of Educational Computing Activities and Resources**

Many of today’s technology-oriented teachers have been using computer systems only since microcomputers came into common use, but as the timeline in Figure 1.2 shows, a thriving educational computing culture predated microcomputers by 20 years. When integrated circuits made computers both smaller and more accessible to teachers and students, microcomputers became a major turning point in the history of the field. Thus, most of the history of computer technology in education is told in two periods: before and after the introduction of microcomputers (Niemiec & Walberg, 1989; Roblyer, 1992). In 1994, yet another technological development, the World Wide Web, transformed educational technology. This development marked the beginning of the third and current era of computers in education.

**Pre-microcomputer era.** Although this era’s computer resources were very different from those of today, both computer companies and educators learned much at this time about the role technology was destined to play in education and who could best shape that role. IBM was a pioneer in this field, producing the first instructional mainframe with multimedia learning stations: the IBM 1500. By the time IBM discontinued it in 1975, some 25 universities were using this system to develop CAI materials. The most prominent of these was led by Stanford University professor and “Grandfather of CAI” Patrick Suppes, who developed the Coursewriter language to create reading and mathematics drill-and-practice lessons. Other similar company- and university-led instructional initiatives ensued: Suppes founded the Computer Curriculum Corporation (CCC); the Digital Equipment Corporation created the PDP-1, the first instructional minicomputer; and the Control Data Corporation (CDC) created the Programmed Logic for Automatic Teaching Operations (PLATO) system and the Tutor CAI authoring language.

For about 15 years, these mainframe and minicomputer CAI systems dominated the field. Universities also developed instructional applications for use on these systems. Among these were Brigham Young University’s Time-shared Interactive Computer-Controlled Information Television or TICCIT system and computer managed instruction (CMI) systems based on mastery learning models, such as the American Institutes for Research’s Program for Learning in Accordance with Needs (PLAN) and Pittsburgh’s individually prescribed instruction (IPI). However, these systems were both expensive to buy and complex to operate and maintain, and school district offices began to control their purchase and use. But by the late 1970s, it was apparent that teachers disliked the control of CAI/CMI applications by both district data processing and industry personnel; they began to reject the idea that computers would revolutionize instruction on a business office model.

**Microcomputer era.** The entire picture changed in the late 1970s with the invention of small, stand-alone desktop microcomputers, which wrested control of educational computers from companies, universities, and school districts and placed them in the hands of teachers and schools. Several different initiatives emerged to shape this new teacher-centered control. A software publishing movement that catered to educators quickly sprang up. With National Science Foundation funding, the Minnesota Educational Computing Consortium (MECC) became the single largest microcomputer software provider, and a multitude of other companies and cottage industries soon followed. To offer advice on how to select quality products, organizations emerged to review software (e.g., Northwest Regional Education Laboratory’s MicroSIFT Project, the Educational Products Information Exchange or EPIE), and professional organizations, journals, and magazines all began to publish software reviews. As teachers clamored for more input into courseware design, companies created authoring languages (e.g., PILOT, SuperPILOT) and menu-based authoring systems (e.g., GENIS, PASS), but teacher authoring soon proved too time consuming, and interest faded. As schools searched for a way to make CAI more cost effective, districts began to purchase networked integrated learning systems (ILSs) with predeveloped curriculum to help teachers address required standards. Control of computer resources moved once again to central servers controlled by school district offices.
Also at this time, computer literacy skills began to be required school and state curricula, spurred on by computer education experts like Arthur Luehrmann. However, this emphasis was soon dropped due to difficulties in defining and measuring these skills. As a result of Seymour Papert's work (1987), products and research based on the Logo programming language became the focus of the field. The Logo view of technology—that computers should be used as an aid to teach problem solving—began to replace traditional instructional computer uses (e.g., drills, tutorials) as the "best use" of technology. Yet despite its popularity and research showing it could be useful in some contexts, researchers could capture no impact from Logo use on mathematics or other curriculum skills, and interest in Logo, too, waned by the beginning of the 1990s.

Internet era. Just as teachers seemed to be losing interest once again in technology's potential for instruction, the first browser software (Mosaic) transformed a formerly text-based Internet into a combination of text and graphics. By the last
part of the 1990s, teachers and students joined the throng of users on the “Information Superhighway.” By the beginning of the 2000s, email, online (i.e., web-based) multimedia, and videoconferencing became standard tools of Internet users, and portable devices made Internet access ubiquitous. The ease of access to online resources and communications drove a dramatic increase in distance learning offerings, first in higher education, then in K–12 schools. As interest in technology in education began to expand once more, the International Society for Technology in Education (ISTE) developed National Educational Technology Standards (NETS) for teachers, students, and administrators.

What Have We Learned from the Past?
In no small part, developments in computer technology have shaped the history of educational technology. However, knowing the history of educational technology is useful only if we apply what we know about the past to future decisions and actions. What have we learned from more than 50 years of applying technology to educational problems that can
improve our strategies now? Educators are encouraged to draw their own conclusions from these and other descriptions they might read. However, the following points also are important:

- **No technology is a panacea for education** — Great expectations for products such as Logo and ILSs have taught us that even the most current, capable technology resources offer no quick, easy, or universal solutions. Computer-based materials and strategies are usually tools in a larger system and must be integrated carefully with other resources and with teacher activities. Cuban (2001) proposes that technology was “oversold” from the beginning and is not having the system-changing impact many thought it would. Trend (2001) proposes that overuse of distance learning can create more problems than it solves. If we begin with more realistic expectations in mind, we have more potential for success and impact on teaching and learning. Planning must always begin with this question: What specific needs do my students and I have that (any given) resources can help meet?

- **Computer/technological literacy offers a limited integration rationale** — Many parents and educators want technology tools in the classroom primarily because they feel technical skills will give students the technological literacy required to prepare them for the workplace. But an employability rationale provides limited guidelines for how and where to integrate technology. The capabilities of technology resources and methods must be matched to skills that display an obvious need for application in our current system of education, for example, reading, writing, and mathematics skills; research and information gathering; and problem solving and analysis.

- **Teachers usually do not develop technology materials or curriculum** — Teaching is one of the most time- and labor-intensive jobs in our society. With so many demands on their time, most teachers cannot be expected to develop software or create complex technology-based teaching materials. In the past, publishers, school or district developers, or personnel in funded projects have provided this assistance; this seems unlikely to change in the future.

- **Technically possible does not equal desirable, feasible, or inevitable** — A popular saying is that today’s technology is yesterday’s science fiction. But science fiction also shows us that technology brings undesirable—as well as desirable—changes. For example, distance technologies have allowed people to attend professional conferences online, rather than by traveling to another location; however, people continue to want to travel and meet face to face. Procedures for human cloning are becoming available, and genetic engineering is increasingly feasible. In education, we can simulate face-to-face communication to an increasingly realistic degree. All of these new technological horizons make it evident that it is time to analyze carefully the implications of each implementation decision. Better technology demands that we become critical consumers of its power and capability. We are responsible for deciding just which science fiction becomes reality.

- **Things change faster than teachers can keep up** — History in this field has shown that resources and accepted methods of applying them will change, often quickly and dramatically. This places a special burden on already overworked teachers to continue learning new resources and changing their teaching methods. Gone are the days—if, indeed, they ever existed—when a teacher could rely on the same handouts, homework, or lecture notes from year to year. Educators may not be able to predict the future of educational technology, but they know that it will be different from the present; that is, they must anticipate and accept the inevitability of change and the need for a continual investment of their time.

- **Older technologies can be useful** — Technology in education is an area especially prone to what Roblyer (1990) called the “glitz factor.” With so little emphasis on finding out what actually works, anyone can propose dramatic improvements. When they fail to appear, educators move on to the next fad. This approach fails to solve real problems and it draws attention away from the effort to find legitimate solutions. Worse, teachers sometimes throw out methods that had potential if only they had realistic expectations. The past has shown that teachers must be careful, analytical consumers of technological innovation, looking to what has worked in the past to guide their decisions and measure their expectations. Educational practice tends to move in cycles, and “new” methods often are old methods in new guise. In short, teachers must be as informed and analytical as they want their students to become.

- **Teachers always will be more important than technology** — With each new technological development that appears on the horizon, the old question seems to resurface: Will computers replace teachers? The developers of the first instructional computer systems in the 1960s foresaw them replacing many teacher positions; some advocates of today’s distance learning methods envision a similar impact on future education. Yet the answer to the old question is the same and is likely to remain so: Good teachers are more essential than ever. One reason for this was described in
Naisbitt's (1984) MegaTrends: "...whenever new technology is introduced into society, there must be a counterbalancing human response ... the more high tech (it is), the more high touch (is needed)" (p. 35). We need more teachers who understand the role technology plays in society and in education, who are prepared to take advantage of its power, and who recognize its limitation. In an increasingly technological society, we need more teachers who are both technology savvy and child centered.

**Why Use Technology? Using Past Research and Practice to Develop a Sound Rationale**

The history of educational technology also teaches us the importance of the "Why use technology?" question. Educators will use new methods if they can see clearly compelling reasons to do so. (See the discussion of "relative advantage" in Chapter 2.) Many educators look to educational research for evidence of technology's present and potential benefits. However, even though electronic technologies have been in use in education since the 1950s, research results have not made a strong case for its impact on teaching and learning. The number and quality of studies on educational impact have been disappointing (Cradler, 2003; Roblyer, Castine, & King, 1988), and researchers such as Clark (1983, 1985, 1991, 1994) have openly criticized "computer-based effectiveness" research such as meta-analyses to summarize results across studies comparing computer-based and traditional methods. Clark concluded that most such studies suffered from confounding variables that could either increase or decrease achievement. They attempt to show a greater impact on achievement of one delivery method over the other without controlling for other factors such as different instructors, instructional methods, curriculum contents, or novelty. Kozma (1991, 1994) responded to these challenges by proposing that research should look at technology not as an information delivery medium but as "the learner actively collaborating with the medium to construct knowledge" (1991, p. 179).

Although the lack of agreement on integration methods and benefits makes it challenging to state a clear and compelling case for using technology in education, four current conditions combine to make it essential that we do so:

- **Increasing costs of keeping up with technology** — The process of integrating technology effectively into education requires substantial investments in technology infrastructure and teacher training. Educators and policy makers need a solid rationale for why these funds are well spent (Ringstaff & Kelley, 2002).

- **Attacks by technology critics** — Justifying technology expenditures by confirming technology's benefits is increasingly important in light of recent volleys of criticisms from noneducators (Healey, 1998; Oppenheimer,
2003). These highly publicized attacks focus on the lack of evidence that technology’s benefits outweigh the problems it causes (e.g., high costs of updating resources, implementation difficulties, potential dangers to students).

- **Low teacher use** — Recent surveys indicate that even teachers who have sufficient training and access to resources are not using technology as much as expected (Cuban, Kirkpatrick, & Peck, 2001; Norris, Sullivan, Poirot, & Soloway, 2003). Clearly, teachers are not hearing a convincing case for technology’s benefits.

- **The influence of the accountability movement and the No Child Left Behind (NCLB) Act** — Passed in 2001, the federal NCLB act is predicted to dominate policy and drive funding for some time to come. One of its most controversial requirements is that funding for proposed expenditures must be tied to “scientifically based research” on effectiveness. Like many educational initiatives, technology integration currently lacks this kind of research base.

**Research evidence.** The Center for Applied Research in Educational Technology (CARET), a funded project of the International Society for Technology in Education (ISTE), has the most comprehensive review of research evidence available on the impact of technology in education (see http://caret.iste.edu). The What Works Clearinghouse (http://w-w-c.org), established by the U.S. Department of Education’s Institute of Education Sciences to provide “high-quality reviews of scientific evidence of the effectiveness of replicable educational interventions,” is also a source for this research evidence.

CARET’s approach to the technology use rationale is based on what educators have been saying for years: Simply having students use technology does not raise achievement. The impact depends on the ways the technology is used and the conditions under which applications are implemented. For example, CARET poses the question, “How can technology influence student academic performance?” It answers this question by citing studies that indicate the application influences performance, not as a delivery system, but as an instruction that works under certain circumstances. Figure 1.3 summarizes research CARET has found about how and under what conditions technology can enhance teaching and learning.

As the CARET project illustrates, the case for using technology in teaching is one that must be made not just by isolating variables that make a difference, but by combining them. Figures 1.4 through 1.7 provide a summary of reasons practitioners have cited over the years for why we should integrate technology into teaching. When viewed together with research findings, they pose a powerful rationale for why technology must become as commonplace in education as it is in other areas of society. They also help point out specific ways to integrate technology into teaching and learning. A summary of the elements underlying a rationale for using technology in teaching is given in Figure 1.8.

**Looking Around: What Factors Shape the Current Climate for Technology in Education?**

The history of educational technology shows us that two general characteristics shape the field’s direction and the impact it will have on teaching and learning: (1) the capabilities of...
resources available at a given time in the evolution of technology; and (2) the combination of current societal influences, educational trends and priorities, economic factors, and company marketing initiatives. This section gives an overview of current technology resources, how they are used, and prevailing factors and issues that are shaping their impact.

**Current Educational Technology Systems, Configurations, and Applications**

Figure 1.9 gives a graphical overview of the technical resources available for teachers to use. Note that all technology integration strategies require a combination of **hardware** or equipment (desktop, laptop, or handheld computer, along with appropriate input/output devices such as printers and scanners) and **software** or programs written to perform various kinds of educational applications. As Figure 1.10 shows, computer equipment can be arranged or configured in various ways, each of which is suited to supporting specific types of integration strategies. Software to support educational technology applications includes these types:

- **Instructional** — Programs designed to teach students skills or information through demonstrations, examples, explanation, or problem solving
- **Productivity** — Programs designed to help teachers and students plan, develop materials, and keep records
- **Administrative** — Programs that administrators at school, state, and district levels use to support record keeping and exchanges of information among various agencies.

Integration strategies described in this textbook focus on instructional and productivity applications that teachers implement. Administrative technology activities (e.g., student and faculty records, report card generation) are covered in other Prentice Hall texts.
Figure 1.5  Why Use Technology? To Enhance Instruction

Practitioners Say That Technology Can Enhance Instructional Methods By:

- **Supplying interaction and immediate feedback to support skill practice**—Software such as the drill-and-practice type offers many students the privacy, self-pacing, and immediate feedback they need to comprehend and retain lower level skills.

- **Helping students visualize underlying concepts in unfamiliar or abstract topics**—Simulations and other interactive software tools have unique abilities to illustrate science and mathematics concepts. Highly trained principles become easier to understand.

- **Illustrating connections between skills and real-life applications**—Technology tools support problem-based learning to help students see where high-level math and science skills apply. Students are less likely to have “inert knowledge,” i.e., knowing how to do a skill but not recognizing where to use it.

  Project-based learning (PBL) re-defines the boundaries of the classroom. The PBL classroom can be a forest or stream, an office or lab, a museum or zoo. The Digital Age is now bringing these environments to students virtually, permitting (them) to travel via the Internet to lava flows in Hawaii or to the Library of Congress. (Chen, 2001, p. 2)

- **Letting students study systems in unique ways**—Students use tools such as spreadsheets and simulations to answer “what if” questions they would not be able to do easily by hand or would not be feasible at all without the benefits of technology.

- **Giving access to unique information sources and populations**—The Internet connects students with information, research, data, and expertise not available locally. Multicultural awareness can increase when students of different cultures interact online (Roblyer, 1991).

  One of the great things about teaching art history is that there’s always going to be new content in the field. What the Web has done is allowed for better access to that new content. And museums, even the smaller ones, are going to have to put their collections online. (Cavalcio, 2003, p. 18)

- **Supplying self-paced learning for capable students**—Self-directed students can learn on their own often with software tutorials and/or distance education materials. They can surge ahead of the class or tackle topics not offered by the school.

  High schooler Rachel of Forks, Washington, loves Virtual High School classes…. She takes two VHS classes per semester, along with regular face-to-face classes. “I like the combination and I like the freedom of working on my own anytime I want.” It all comes down to self-motivation and whether or not a student can work independently. (Furger, 2002, p. 17)

- **Allowing access to learning opportunities**—Students with disabilities depend on technology to compensate for vision, hearing, and/or manual dexterity they need in order to read, interact in class, and do products to show what they have learned.

- **Providing opportunities and support for cooperative learning**—Although students can do small group work without technology, teachers report that students are often more motivated to work cooperatively on hypermedia, database, and web page production projects.
**Practitioners Say That Technology Makes Teacher and Student Work More Productively by:**

- **Saving time on production tasks**—Software tools such as word processing, desktop publishing, and spreadsheets allow quick and easy corrections to reports, presentations, budgets, and publications.
  
  Systems are difficult to change. ... Technology, however, often demonstrates a better, faster way of doing things and ... can lead to transforming systems. (Lucas, 2003, p. 2)

- **Grading and tracking student work**—Integrated learning systems and handheld computers help teachers quickly assess and track student progress.

- **Providing faster access to information sources**—Students use the Internet and e-mail to do research and collect data that would take much longer to receive by traditional delivery methods.

  Trying to find information about cultures and religions can be a daunting experience, particularly if you are from a region with limited library service. Filling the void is KidsConnect, which pairs 84 volunteer school librarians like me on the Internet with students from around the world who need answers to questions. (Brangwin, 2002, p. 13)

- **Saving money on consumable materials**—Software tools such as drill and practice and simulations save schools by taking the place of many materials (e.g., worksheets, handouts, dissection animals) that are used and replaced each year.

**Practitioners Say That Technology Can Help Students Learn andSharpen Information Age Skills in:**

- **Technological literacy**—Technologies such as word processing, spreadsheets, simulations, multimedia, and the Internet have become increasingly essential to many job areas. Students who use these in school have a head start on what to do in the workplace.

  “Technology should be a natural component of everything [students] do,” says Heather Sinclair, district director of secondary curriculum and staff development for Lake Washington. “It should be a natural tool they use on a day-to-day basis. It shouldn’t be something that is scary or contrived. It should be authentic and realistic.” PowerPoint® is becoming routine. Students also make videos using digital cameras and movie editing software. They burn their own CDs. They use the Internet to converse with their mentors and conduct research. One student created a steam engine out of Plexiglas; another used computer-aided design (CAD) software to design a sailboat. (GLEF Staff, 2003, p. 9)

- **Information literacy**—Students learn skills that Johnson and Eisenberg (1996) call the “Big Six” (task definition, information-seeking strategies, location and access, use of information, synthesis, and evaluation).

- **Visual literacy**—Images continue to replace text as communication media. Students must learn to interpret, understand, and appreciate the meaning of visual messages; communicate more effectively through applying the basic principles and concepts of visual design; produce visual messages using the computer and other technology; and use visual thinking to conceptualize solutions to problems (Christopherson, 1997, p. 173). Some research correlates visual literacy with higher scores on intelligence tests (Roblyer, 1986).

*Edutopia* is the newsletter for the George Lucas Educational Foundation. It is available online at http://www.glef.org.
Figure 1.8 Why Use Technology? A Summary of Elements Underlying a Rationale

1. Motivation:
   - Ways of gaining learner attention
   - Support for manual operations in high-level learning
   - Illustrations of real-world relevance
   - Engagement in production work
   - Connections with distance audiences

2. Enhanced instructional methods:
   - Interaction and immediate feedback
   - Visual demonstrations
   - Illustrative connections between skills and applications
   - Opportunities to study systems in unique ways
   - Unique information sources and populations
   - Self-paced learning
   - Access to learning opportunities
   - Cooperative learning

3. Increased productivity:
   - Saving time on production tasks
   - Grading and tracking student work
   - Faster access to information sources
   - Saving money on consumable materials

4. Required Information Age skills:
   - Technological literacy
   - Information literacy
   - Visual literacy

An Overview of Today's Big Issues in Education and Technology: Societal, Educational, Cultural/Equity, and Legal/Ethical

One reason that teaching is so challenging is that it occurs in an environment that mirrors—and sometimes magnifies—some of society's most profound and problematic issues. Adding computers to this mix makes the situation even more complex. Yet to integrate technology successfully into their teaching, educators must recognize and be prepared to work in this environment with all of its subtleties and complexities. Some of today's important issues and their implications for technological trends in education are described in the following sections and summarized in Figures 1.11 through 1.14. The full URLs for many of the reports and articles in these figures are given on the Companion Website (http://www.prenhall.com/roblyer). Readers are encouraged to review them to broaden their insights into the impact of these issues.

Societal Issues Shaping Current Technology Uses

The economic, political, and social trends listed in Figure 1.11 have a great impact on whether or not innovations take hold, or have limited acceptance, or are ignored completely. Societal issues that are helping to shape
### Figure 1.10 Types of Technology Facilities and How They Are Used

<table>
<thead>
<tr>
<th>Types of Facilities</th>
<th>Uses</th>
<th>Benefits</th>
<th>Limitations/Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laboratories</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(usually 20–30 networked computers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>All labs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="All labs" /></td>
<td>Centralized resources are easier to maintain and secure; networking software can monitor individual performance in groups</td>
<td>Need permanent staff to supervise and maintain resources. Students must leave their classrooms to use them.</td>
<td></td>
</tr>
<tr>
<td><strong>Special-purpose labs</strong></td>
<td>- Programming or technical courses</td>
<td>Permanent setups of group resources specific to the needs of certain content areas or types of students.</td>
<td>Usually exclude groups who do not meet special purpose. Isolate resources.</td>
</tr>
<tr>
<td><img src="image" alt="Special-purpose labs" /></td>
<td>- Technology education/ vocational courses (e.g., with CAD, robotics, desktop publishing stations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Special-purpose labs" /></td>
<td>- MIDI music labs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Special-purpose labs" /></td>
<td>- Labs dedicated to content area(s), e.g., mathematics/science, foreign languages</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Special-purpose labs" /></td>
<td>- For use by Chapter or Title III students</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Special-purpose labs" /></td>
<td>- Multimedia production work</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Special-purpose labs" /></td>
<td>- Teacher work labs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>General-use computer labs</strong></td>
<td>Student productivity tasks (e.g., word processing, multimedia production); class demonstrations; student project work</td>
<td>Accommodate varied uses by different groups.</td>
<td>Difficult to schedule specific uses. Usually available to only one class at a time.</td>
</tr>
<tr>
<td>(open to all school groups)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Library/media center labs</strong></td>
<td>Same as for general-use labs</td>
<td>Same as for general-use labs, but permanent staff are already present. Ready access to all materials to promote integration of computer and noncomputer resources.</td>
<td>Same as for general-use labs. Staff members need special training. Classes cannot usually do production or group work that may bother other users of the library/media center.</td>
</tr>
<tr>
<td><strong>Mobile Computers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a.k.a. computers on wheels or COWs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mobile workstations</strong></td>
<td>Demonstrations, short-term uses</td>
<td>Stretch resources by sharing them among many users; supply on-demand access.</td>
<td>Moving equipment can cause breakage and other maintenance problems. Sometimes difficult to get through doors or up stairs. Can increase security problems.</td>
</tr>
</tbody>
</table>

(continued)
the current climate for educational technology include the following:

- **Economic conditions** — Recent economic downturns in the U.S. economy have meant decreased education funding. Experts predict that funds will not return to previous levels when the economy improves.

- **Anti-technology positions** — Some critics say that ubiquitous technology interferes with privacy and complicates daily life. Others feel that teaching/learning benefits have not been clearly established, and that technology is not as important as other programs that are being cut (e.g., music, arts). Still others say that computer use poses potential health hazards and that Internet cyberporn and predators pose other risks, especially to young users.

- **Impact of the NCLB Act of 2001** — Among other things, the NCLB act requires that all government-funded programs demonstrate benefits with “scientifically based research,” and schools must demonstrate that all students are meeting standards.


This combination of social conditions means that educators increasingly are forced to set priorities for scarce education dollars. In light of this and recent attacks on technology by those outside education, it is even more important to use research results and best practice findings to establish a sound rationale for technology use and justify technology expenses and potential risks to student users. Increasingly, funding for technology-based strategies will be dependent on these results and findings. In light of increasing accountability requirements, it also seems likely that schools will begin emphasizing the use of computer systems to track student progress.

### Educational Issues Shaping Current Technology Uses

Trends in the educational system are intertwined with trends in technology and society. The three kinds of educational issues shown in Figure 1.12 and listed next have special implications for the ways technology will be used in teaching and learning:

- **Standards movement** — All content areas and states have skill standards students must meet to pass courses and to get degrees and certification. High-stakes tests on standards determine success. This movement may drive a trend toward using technology
in ways that help teachers and students pass tests and meet required standards.

- **Reliance on the Internet and on distance education** — Increasing numbers of virtual K–12 courses are being offered, and virtual high schools are becoming commonplace in U.S. education. This means that students could have increased access to high-quality courses and degrees. However, virtual learning takes special skills not all students have, and dropout rates from distance courses are higher, which could further widen the **Digital Divide**. Some critics say that distance learning is not as empowering as a face-to-face educational experience.

- **Debate over directed vs. inquiry-based, constructivist instructional methods** — Educators disagree on the proper roles of traditional, teacher-directed learning versus student-led, inquiry-based methods. Long-used and well-validated directed uses of technology have been shown to be effective for addressing standards, but many educators see them as passé. Inquiry-based, constructivist methods are considered more modern, but it is less clear how they could address required standards.

### Cultural and Equity Issues Shaping Current Technology Uses

The three factors shown in Figure 1.13 and listed next reflect the complex racial and cultural fabric of our society, and they continue to have a great impact on technology use:

- **Digital Divide** — A phrase coined by Lloyd Morrisett, former president of the Markle Foundation, the Digital Divide refers to a discrepancy in access to technology resources among socioeconomic groups. The single greatest factor determining access is economic status, although race and gender may also play a role, depending on the type of technology. Recent studies (Corporation for Public Broadcasting, 2003) find that while children from all income levels have greatly increased their Internet use, children from underserved populations (e.g., low-income and minority students) still lag far behind other students in home and school access.

- **Racial and gender equity** — Technology remains dominated by males and certain ethnic groups. Studies show that when compared with males and whites, females, African Americans, and Hispanic minorities use computers less and enter careers in math, science, and technology areas at lower rates. Many educators believe these two findings are correlated: Lower use of technology leads to lower entrance to technical careers. Even where computers are available in schools, there tends to be unequal access to certain kinds of activities. For example, children in Title I programs may have access to computers, but use them mainly for remedial work rather than for email, multimedia production, and other personal empowerment activities.

- **Special needs** — Devices and methods are available to help students compensate for their physical and mental deficits and allow them equal access to technology and learning opportunities. However, technological interventions that could help students with special needs are difficult to purchase and implement and often go unused. Parents clamor for the technology resources guaranteed their children by federal laws, but schools often claim insufficient funding to address these special needs.
As Molnar pointed out in his landmark 1978 article “The Next Great Crisis in American Education: Computer Literacy,” the power of technology is a two-edged sword, especially for education. While it presents obvious potential for changing education and empowering teachers and students, technology also may further divide members of our society along socioeconomic, ethnic, and cultural lines and widen the gender gap. Teachers will lead the struggle to make sure technology use promotes, rather than conflicts with, the goals of a democratic society.

**Legal and Ethical Issues Shaping Current Technology Uses**

In many ways, technology users represent the society in a microcosm. The legal and ethical issues educators face reflect those of the larger society. The three major kinds of ethical and legal issues shown in Figure 1.14 and discussed next have great impact on how technology activities are implemented:

- **Viruses/hacking** — Illegal activities of two kinds are on the rise: (1) Viruses, or programs written to cause damage or do mischief; cause problems ranging from lost files to systems being shut down for weeks. (2) Hackers are breaking into online systems in order to access personal data on students, accomplish identify theft, and do other malicious acts. To combat these problems, schools are forced to install firewalls and virus protection software to safeguard classroom computers, and to spend larger portions of technology funds each year on preventing and cleaning up after illegal activities.

- **The new plagiarism** — Greater online access to full-text documents has resulted in increased “cybercheating,” or students using materials they have found on the Internet as their own. Sites have emerged to help teachers catch plagiarizers, and the number of educational organizations and teachers using them is increasing.

- **Privacy/safety** — Increasing amounts of students’ personal information are being placed online and students are spending more time using online resources. At the same time, studies show a high incidence of attempts by online predators to contact students, and objectionable material is readily available and easy to access. To address these concerns, schools are requiring students/parents to sign an Authorized Use Policy (AUP) and putting procedures in place to safeguard access to students’ personal information. Schools have also been put on notice to supervise carefully all student use of the Internet, and to install filtering software to prevent access to objectionable materials.

- **Copyright** — Online availability of full-text publications is increasing, and distance courses are posting more materials in online course management systems. To make sure they comply with copyright laws, schools are making teachers and students aware of policies about copyright/AUP and fair use of published materials.

- **Illegal downloads/software piracy** — An increasing number of sites offer ways to download copies of software or other media without paying for them, and software and media companies are prosecuting more offenders. Despite the ease of copying or downloading free materials, teachers are tasked with modeling and teaching ethical behaviors with software and media.

The culture, language, and problems of the larger society also emerge among technology users, and their activities reflect many of the rules of conduct and values of society in general. Teachers who use technology are faced
TOP TEN ISSUES SHAPING TODAY'S TECHNOLOGY USES IN EDUCATION

1. Accountability and the standards movement — Educators want to know (a) how technology can help students meet required curriculum standards and (b) what role technology skills play in children's education.

2. Funding for educational technology — As technology costs grow and education funds wane, policymakers ask, "How can we justify spending scarce education dollars on technology?"

3. The Digital Divide — Since technology access differs between wealthy and poorer schools, people want to know if technology is deepening the economic chasm between rich and poor.

4. Racial and gender equity — Science, technology, and engineering careers remain dominated by males and certain ethnic groups; educators say more student involvement in technology at earlier levels could change this picture.

5. The role of distance education — Virtual schools are springing up around the country. Parents wonder: (a) Can all students succeed in online environments? (b) Will students learn as much as in face-to-face classrooms?

6. Privacy and safety — As more student data go online and students spend more time on the Internet, measures have to be put into place to limit access to personal data and to protect students from online predators.

7. Viruses and hacking — The online community is seeing an unprecedented number of viruses and illegal entries into networks. Schools are forced to spend precious funds on measures to protect themselves.

8. Online plagiarism — Students have easy access to papers and projects they can turn in as their own. Teachers have to be on the alert for plagiarism and use online sources to check suspicious work.

9. Anti-Technology sentiments — In light of the scarcity of research on technology's impact on indicators of education quality, critics of educational technology are on the attack.

10. Information literacy — Society's increasing dependence on technology to communicate information means that students must learn skills to use information technologies effectively.

Looking Ahead: What Developments in Technology Integration Are Emerging?

Emerging Trends in Hardware and Software Development

Visions of the future are suffused with images of technologies that may seem magical and far-fetched now, just as cellular phones and fax machines seemed only a few decades ago. And, although the technology images we see when we look into the future of education are murky and ill defined, we know that they will mirror current technical trends and the goals and priorities we set today for tomorrow's education. As with so many "miraculous" technologies, the question is how we will take advantage of their capabilities to bring about the kind of future education systems our society wants and our economy needs.

Future technological developments will have such a profound impact on education that the federally funded Institute for the Advancement of Emerging Technologies in Education (IAETE) at the Appalachian Educational Laboratory (AEL) was founded specifically to study and document leading-edge technologies with promising educational practices. IAETE's latest findings on innovations in education and the emerging technologies associated with them are documented at its website (http://www iaete org) and in its annual publication, INSIGHT.

Just as the Internet changed communications capabilities in ways that shaped educational practices, other technological developments will have equally dramatic con-
sequences for schools. One such technology may be radio-frequency identification (RFID), which consists of a computer chip and an electronic monitoring system that tracks the location of the chip and can update information on it. First introduced in department stores to monitor inventory and prevent theft of goods, RFID is already being proposed to track student attendance, increase school security, and monitor the location of library resources (Murray, 2003b). Some educators envision even more school-related RFID uses and say it has the potential to save time that can be redirected to teaching activities. However, six other trends in technological developments, summarized in Figure 1.15, promise to have even more direct impact on teaching and learning activities: wireless connectivity, merged technologies, handheld devices, high-speed communications, artificial intelligence, and virtual systems.

- **Trend #1: Wireless connectivity** — A universal trend across computer systems, wireless connections are simplifying computer networks by reducing the number of required cables and allowing greater freedom of movement. Instead of each computer having a “drop” or cabled access point to the network, wireless networks have one drop through which many computer devices access the network. One result is mobile labs on a cart that contains from 10 to 30 laptops and a wireless access point that can be plugged into a network jack. Some schools have “hot spots” or drops around the building, so that students can use a portable computer anywhere in the school.

- **Trend #2: Merging of technologies** — An ever-increasing number of devices combine communications capabilities that were once housed in individual devices. For example, cellular phones now allow not only voice communications, but also can create and send digital images and text messages. Handheld devices often incorporate the power of desktop computers and the capabilities of digital cameras.

- **Trend #3: Developments in portable devices** — Computers are becoming increasingly portable, which allows teachers and students greater flexibility in learning environments. Laptops are becoming more popular, along with handheld computers (a.k.a. “palms”) and tablet PCs. Many schools are replacing their desktop computers with these portable devices so that learning activities need not be confined to classrooms or school buildings.

- **Trend #4: Availability of high-speed communications** — Imitating the gradual spread of electrical power and telephone access into all parts of the United States during the early 1900s, high-speed Internet connections are becoming increasingly ubiquitous in the 2000s. Faster connections made possible by Digital Subscriber Lines (DSLs) and cable modems mean higher quality, more reliable voice and video communications, which are the necessary ingredients to make distance learning environments emulate face-to-face ones.

- **Trend #5: Visual immersion systems** — Once only dreamed of in science fiction, computer-generated environments that immerse students in simulated worlds are becoming increasingly available. Current applications include full immersion systems with head-mounted displays, augmented reality systems, and 3-D models on computer screens. Although full-immersion systems are still too expensive for most schools, experimental applications continue to appear sporadically. Virtual 3-D models on computer screens are becoming more prevalent (Parham, 2003; Thatcher, 2003). Some experts predict increased use of augmented reality systems, which allow people with computer-powered goggles to view real-world images with overlays from global positioning system (GPS) satellites (Augmented reality, 2002).

- **Trend #6: Intelligent applications** — Artificial intelligence (AI) has never had the same level of impact on education as it has had on activities such as chess playing and industrial training and problem solving. However, applications of so-called “intelligent programs” (software that emulates human thought processes and responses to situations) continue to appear in education as researchers explore ways to use AI-type capabilities to solve persistent problems in instruction and assessment.

**Implications of New Technologies for Teachers and Students**

The six trends just discussed promise significant changes in the way education is carried out. The changes in educational practices are gradual, and current examples are usually limited to pilot programs and studies. However, the technologies described here are advancing so quickly in other areas of society, it is easy to imagine a future where they are commonplace in education.

- **Flexible learning environments** — No longer do students have to leave classrooms for “pull-out” activities in labs. With wireless communications and portable devices, now the lab comes to the students, and learning environments can be located beyond the walls of classrooms and schools. Students can take notes, gather data, or do research from wherever they are and have easy, fast access to resources such as writing labs and digital production labs. Tinker, Staudt, and Walton (2002) describe an example of the power this flexibility offers on a field trip to do scientific observations, and Curtis, Williams, Norris, O’Leary, and Soloway (2003) describe...
<table>
<thead>
<tr>
<th>Emerging Trends</th>
<th>Examples</th>
<th>Implications for Technology Integration Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wireless connectivity</strong></td>
<td>- Mobile labs</td>
<td>- Mobility makes it easier for teachers to plan for and implement activities.</td>
</tr>
<tr>
<td></td>
<td>- School-wide hot spots (wireless connections to networks)</td>
<td>- Easier access to networks makes it easier to obtain materials, update assessments.</td>
</tr>
<tr>
<td>[Image]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Merging of technologies</strong></td>
<td>- Handheld devices with built-in communications and digital imaging capabilities</td>
<td>- Combined capabilities mean fewer devices to buy and keep track of during instruction.</td>
</tr>
<tr>
<td>[Image]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Developments in portable devices</strong></td>
<td>- Laptops</td>
<td>- Portability makes it easier for each student to have a computer, thus allowing individualized strategies.</td>
</tr>
<tr>
<td></td>
<td>- Multipurpose handheld devices</td>
<td>- Students can write and do research from any location.</td>
</tr>
<tr>
<td></td>
<td>- Tablet PCs</td>
<td>- Teachers can do continuous monitoring and assessment.</td>
</tr>
<tr>
<td>[Image]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Availability of high-speed communications</strong></td>
<td>- In homes: Digital Subscriber Lines (DSL) and cable modems</td>
<td>- High-quality, reliable voice and visual communications make distance learning more like face-to-face classrooms.</td>
</tr>
<tr>
<td></td>
<td>- In schools: T1 lines, DSL, and cable modems</td>
<td>- More students have access to virtual courses and degree programs.</td>
</tr>
<tr>
<td>[Image]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Visual immersion systems</strong></td>
<td>- Head-mounted VR systems,</td>
<td>- Students with physical limitations can simulate movement in real situations.</td>
</tr>
<tr>
<td></td>
<td>- Augmented reality systems</td>
<td>- Simulated systems allow more realistic and authentic presentations of information.</td>
</tr>
<tr>
<td></td>
<td>- 3-D imaging systems</td>
<td></td>
</tr>
<tr>
<td>[Image]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intelligent applications</strong></td>
<td>- Intelligent grading systems</td>
<td>- Computer systems grade complex performances (e.g., writing) more quickly and reliably than teachers.</td>
</tr>
<tr>
<td></td>
<td>- Intelligent tutors</td>
<td>- Computer tutors adapt more quickly to individual students' learning needs.</td>
</tr>
</tbody>
</table>
how to manage and carry out lessons that maximize the flexibility of handheld devices. One study has already indicated that teachers find handheld devices easy to integrate into classroom activities (Branigan, 2002a).

- **Adaptable assessment options** — New technologies are already having an impact on how educators assess students, and more changes seem likely in the future. Teachers are beginning to use handheld devices to make monitoring students’ progress more immediate and continuous (Hudgins, 2001). As standards and accountability loom ever larger on the horizon, continuous assessment becomes more important, making it easier to guide student progress and ensure success on tests. The Pennsylvania Department of Education found that an intelligent system for scoring the essay portion of state-mandated tests matched an expert reviewer’s scores more often than reviewers matched each other (Branigan, 2000). This indicates that faster, cheaper updates to current methods of assessing complex performances such as writing may not be far away.

- **Reliance on distance learning** — As high-speed connections become more readily available to schools and homes, the number of students learning through virtual systems is steadily increasing (Zucker & Kozma, 2003). Many states sponsor a virtual high school, and many organizations offer courses for junior high and even elementary students (Roblyer, 2003b). Though currently fraught with controversy, distance learning for K–12 students eventually will have the same degree of impact on reshaping schools as it has had on redefining higher education.

- **Support for people with disabilities** — New technologies continue to make the most dramatic advances in opportunities for people with disabilities. Kurzweil (2003) describes immersion systems and intelligent programs that help people with sensory impairments and physical disabilities function effectively in learning situations. Branigan (2002b) describes a virtual reality project that has dramatically improved the performance of students with hearing impairments. Because the No Child Left Behind Act requires that all students, including those with disabilities, meet high standards of achievement, it seems likely that schools will increase their investments in new assistive technologies (Assistive technologies, 2003).

The National Council for the Accreditation of Teacher Education (NCATE), the agency responsible for accrediting colleges of education, has joined with ISTE in not only establishing standards for teaching about technology in education, but also in saying that schools of education should increase their emphasis on the use of technology in teacher training (NCATE, 1997). Thus, the ISTE National Educational Technology Standards (NETS) for Teachers have become the benchmark for technology infusion in teacher education programs. NETS for Teachers are specified for each chapter, technology integration idea, and all end-of-chapter activities in this text. The student version of these standards is also shown at the front of this book. It is important to note the relationship between these sets of standards. NETS for Students are considered basic skills that students—and their teachers—should meet.

### How Teachers Can Demonstrate Their Skills: Electronic Portfolios

Many teacher preparation programs require their candidates to develop a teaching portfolio as they go through the program. Portfolios are a collection of student’s work products over time, arranged so that they and others can see how their skills have developed and progressed. They also include criteria for selecting and judging content. The portfolio concept originated in higher education with colleges of arts, music, and architecture. Work in these areas could not be measured well through traditional tests. Instead of final exams, these students had to have a professional portfolio when they graduated to demonstrate their level of accomplishment in their field. For today’s technology-integrated curriculum, which often calls for multimedia work products, many teachers are turning to student electronic portfolios as the assessment strategy of choice. Although older students could decide on their own portfolio format, teachers usually provide the portfolio structure and tell students how to fill in the content. Teachers can choose from several kinds of resources for these structures:

- **“Ready-made” software packages** — These include Learner Profile (Sunburst), Grady Profile (Auerbach), and My ePortfolio (Learning Quest). Teachers can use these instead of creating their own structure. These systems usually are built on database software, with fields to attach files of written and visual products.

- **PDF documents** — To store and display documents (with or without graphics), teachers can use Adobe Acrobat software to create electronic versions of pages. These are essentially “pictures of pages” and are easy to store and share with others.

---

Skills for the Future: ISTE NETS for Students, Teachers, and Administrators

Clearly, 21st-century educators will have to deal with issues that their predecessors could not even have imagined. Both they and the students they teach must have skills and knowledge that will prepare them to meet these new challenges.
Figure 1.16  Electronic Teaching Portfolios: How to Create and Use Them

1. Determine portfolio requirements
   Find out products required, medium to use, and criteria to meet
   See rubric for evaluating portfolio quality at
   http://www.uwstout.edu/soe/prodev/eportfoliorubric.html

2. Create the structure
   Set up the portfolio sections on the medium (e.g., web, PowerPoint, portfolio software) you have chosen

3. Add and link components
   Create media and software products and add to portfolio structure by required deadlines

4. Monitor the collection and receive periodic feedback
   Review products with instructors; determine if criteria are being met

5. Reflect on the products and revise as needed
   Add or change components based on feedback

NOTE: The American Association for Higher Education (AAHE) has developed a book on how to create electronic portfolios (Electronic Portfolios: Emerging Practices in Student, Faculty, and Institutional Learning, AAHE, 2002) and a searchable database of sample e-portfolios. For more information, see http://aahe.ital.utexas.edu/electronicportfolios/index.html.


- **Multimedia authoring software** — Early multimedia structures were in HyperCard or HyperStudio, but some teachers now structure portfolios with packages such as Microsoft PowerPoint, Macromedia Director, Travantis Lectora, or eZedia's eZediaQTI. These packages allow for advanced and sophisticated video and audio presentations.

- **Databases** — Relational database software such as FileMaker Pro is helpful to teachers who must keep track of many students' work. They offer teachers the advantage of cataloging work and creating profiles of achievement across groups of students.

- **Websites** — Portfolios also may be posted on the Internet, where they can be more easily shared with others. Like multimedia packages, these portfolios can offer sophisticated video and audio presentations. Companies that act as hosts for electronic portfolios are listed at http://electronicportfolios.com/portfolios/bookmarks.html#vendors.

- **Video** — Although analog video offered only a low-cost, linear format, digital video offers much more flexible, interactive formats to display portfolio elements.

Figure 1.16 shows a suggested sequence to follow to create an electronic portfolio. Also see Barrett (2000) and her collection of portfolio resources at http://electronicportfolios.com/ for more advice on portfolio development, and Hanfland (1999) for tips on portfolio development for young children.

**Interactive Summary**

The following is a summary of the main points covered in this chapter. To see additional examples and information on these points, go to this textbook's Companion Website at http://www.prenhall.com/roblyer and click on the Chapter 1 Interactive Summary module to visit each of the recommended websites.
1. Four perspectives that define educational technology: The following educational technology organizations represent the four views of educational technology described in this chapter:
   - AECT — Technology as media and AV communications
   - ISPI — Technology as instructional systems and instructional design
   - ITEA — Technology as vocational training (a.k.a., technology education)
   - ISTE — Technology as computer systems.

2. History of educational computing technology and what we have learned from it: The three eras in the history of educational computing/technology were:
   - Pre-Microcomputer Era (1950–late 1970s) — University projects use mainframe and minicomputer systems to deliver instruction in schools; the computer literacy movement begins.
   - Microcomputer Era (late 1970s–1994) — Microcomputers enter schools and spawn the software publishing, Logo, and ILS movements.
   - Internet Era (1994–present) — The first web browser (Mosaic) makes possible travel on the Information Superhighway.

3. A rationale for using educational technology: Elements of a rationale for using technology in education include increased motivation, unique instructional capabilities, support for new instructional approaches, increased productivity, and required skills for an information age (technological literacy, information literacy, and visual literacy). The research rationale for using technology in teaching is documented at the CARET website.

4. Current educational technology systems, configurations, and applications: Get some ideas on designs for computer labs and what factors you should consider as you purchase and set up labs. Also, look at pictures of computers on wheels (COWs) and mobile labs. Remember that one of the primary concerns in setting up and maintaining any computer lab is accessibility for all users. Review this accessibility checklist for all the factors that should be considered.

5. Factors shaping the climate for technology integration: These include current educational technology systems, configurations, and applications. Issues include
   - Societal (economic, anti-technology positions, impact of the No Child Left Behind Act
   - Educational (standards movement, reliance on Internet and distance education, and debate over directed vs. constructivist methods)
   - Cultural and equity (Digital Divide, racial and gender equity, special needs)
   - Legal and ethical (viruses/hacking, online plagiarism, privacy/safety, copyright, illegal downloads/software piracy).

6. Emerging trends in hardware/software development: These include:
   - Wireless connectivity
   - Merging of technologies
   - Developments in portable devices
   - Increasingly high-speed communications (e.g., through cable modem and DSL)
   - Visual immersion systems
   - Intelligent applications

7. New skills for the future: The International Society for Technology in Education established the National Educational Technology Skills (NETS) for students, teachers, and administrators. These standards document skills that will be essential in order to take advantage of emerging technology capabilities. People often use electronic portfolios to demonstrate technology and other skills they have attained.

Online Activities
Visit this text’s Companion Website at http://www.prenhall.com/roblyer to gain access to a variety of questions, activities, and exercises to help build your knowledge of this chapter’s content.

Online Chapter 1 Self-Test
To review terms and concepts for this chapter, click on the Self-Test module for this chapter of the Companion Website.

Software Skill-Builders Tutorials
To access practical tutorial and skill-building activities that will help you build skills using popular software and hardware, click on the Software Skill-Builders Tutorials module for this chapter of the Companion Website.

Web-Enrichment Activities
To complete activities that connect to chapter content and provide web-based resources, click on the Web-Enrichment Activities module for this chapter of the Companion Website.