INTEGRATING EDUCATIONAL TECHNOLOGY INTO TEACHING

University of Phoenix

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Taken from

Integrating Educational Technology into Teaching, Second Edition
by M.D. Roblyer and Jack Edwards

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Contents

Section One

Educational Technology in Context: The Big Picture

Science is a process, not an edifice, and sheds old concepts as it grows.

Timothy Ferris in *Coming of Age in the Milky Way* (1988)

The more we know of our heritage, the more we earn the right to lead the field forward in our own time.

Don Ely in Paul Saettler's *The Evolution of American Educational Technology* (1990)

This section covers the following topics:

- Various definitions of key educational technology terms and how they originated
- A brief history of computer technology in education and what we have learned from it
- Justification for technology purchases by relating them to potential improvements in teaching and learning
- An overview of current technology systems and applications in education and the major issues and concerns that guide their uses
- Issues that shape technology's current and future role in restructuring education

Objectives

1. Given an evolving definition of the term educational technology, give four different aspects of that definition and identify professional associations and events 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. Identify reasons that would and would not be appropriate to help justify a school or district purchase and use of technology.
4. Identify the general categories of educational technology hardware resources: standalone computer, network, centralized processor, and related device/system.
5. Identify the general categories of educational technology software resources: instructional software, software tool, multimedia, distance learning, or a virtual reality environment.
6. Explain the impact of each of the following societal issues on current uses of technology in education: cultural diversity, educational equity, ethical practices, and the increasing role of technology in modern life.

When a classroom teacher browses the Internet for new teaching materials or has students look up a definition in an on-disc word atlas, that teacher is using some of the latest and best of what is commonly called *technology in education* or *educational technology*. But educational technology is not new at all, and it is by no means limited to the use of equipment, let alone electronic equipment. Modern tools and techniques are simply the latest developments in a field that some believe is as old as education itself.

In his excellent, comprehensive historical description, *The Evolution of American Educational Technology* (1990), Paul Saettler begins by pointing out that "Educational technology . . . can be traced back to the time when tribal priests systematized bodies of knowledge, and early cultures invented pictographs or sign writing to record and transmit information. . . . 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" (p. 4).

This section explores the link between the early applications of educational technology and those of today and tomorrow. This exploration includes some historical and technical background. Many readers will grow impatient when they encounter these paragraphs of description and explanation. This impatience is understandable in a field where the real excitement for teachers and students lies in hands-on exploration of the newest gadgets and techniques. We encourage you to read for three reasons:

- **Looking back before going ahead.** This information shows where the field is headed by demonstrating where it began. It points out the current status in the evolution of the technology of education along with changes in goals and methods over time. It provides a foundation on which to build more successful and useful structures to respond to the challenges of modern education.
- **Learning from past mistakes.** This background also helps those just embarking on their first applications of educational technology to make the best use of their learning time by avoiding mistakes that others have made and by choosing directions that experience has shown to be promising.
- **Developing a "big picture."** Finally, this background helps new learners to develop mental pictures of the field, what Ausubel (1968) might call *cognitive frameworks* through which to view all applications—past, present, and future.

What Is "Educational Technology"?

Origins and Definitions of Key Terms

Teachers will see references to the terms *educational technology* and *instructional technology* in many professional journals. Perhaps no other topics are the focus of so much new development in so many content areas, yet no single, acceptable definition for these terms dominates the field. Paul Saettler, a recognized authority on the history of instructional and educational technology, notes uncertainty even about the origins of the terms. The earliest reference he can confirm for the term educational technology was in an interview with W. W. Charters in 1948; the earliest known reference he finds for the term instructional technology was in a 1963 foreword by James Finn for a technology development project sponsored by the National Education Association.

For many educators, any mention of technology in education immediately brings to mind the use of some device or a set of equipment, particularly computer equipment. Muffoletto (1994) says that "Technology is commonly thought of in terms of gadgets, instruments, machines, and devices . . . most (educators) will defer to technology as computers" (p. 25). Only about 15 years ago, a history of technology in education since 1920 placed the emphasis on radio and television, with computers as an afterthought (Cuban, 1986). If such a description were written now, the Internet might be a central focus. Twenty years from now the focus might be Intelligent Computer Assisted Instruction (ICAI) or Virtual Reality (VR) or whatever they are called then.

In one sense, all these views are correct, since definitions of state-of-the-art instruction usually mention the most recently developed tools. But Saettler (1990) urges those seeking precision to remember that "the historical function of educational technology is a *process* rather than a product. No matter how sophisticated the media of instruction may become, a distinction must always be made between the process of developing a technology of education and the use of certain products or media within a particular technology of instruction" (p. 4). 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). Based on this background, the authors assign educational technology the following "evolving" definition:

> *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 their related technologies.*

Four Perspectives on Educational Technology: Media, Instructional Systems, Vocational Training, and Computers

If educational technology is viewed as both processes and tools, it is important to begin by examining four different

Figure 1-1 **Four Perspectives That Shaped Educational Technology**

Four Historical Perspectives	Origins	Current Organization
Media and AV communications	Higher education instructors, 1930s	AECT
Instructional systems	Military/industrial trainers; later, university R&D, 1960s–1970s	ISPI
Vocational training (technology education)	Industry trainers, vocational educators, 1980s	ITEA
Computer systems (educational computing)	Programmers, systems analysts; later, university R&D, 1960s	ISTE

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 whose origins and views are summarized in Figure 1-1.

Technology in education as media and audiovisual communications. The earliest view of educational technology and one that continues today emphasizes technology as media. This view grew out of what Saettler (1990) calls the *audiovisual movement*: ways of delivering information used as alternatives to lectures and books. Beginning in the 1930s, some higher education instructors proposed that media such as slides and films delivered information in more concrete, and therefore more effective, ways. This perspective later developed into *audiovisual communications,* the "branch of educational theory and practice concerned primarily with the design and use of messages which control the learning process" (Saettler, 1990, p. 9). However, the view of technology as media continued to dominate areas of education and the communications industry. Saettler reports that as late as 1986, the National Task Force on Educational Technology used a definition that equated educational technology with media, treating computers simply as another medium.

The Association for Educational Communications and Technology (AECT) tends to represent this view of technology as media and communications systems. Originally a department of the National Education Association (NEA) that focused on audiovisual instruction, the AECT was until very recently concerned primarily with devices that carry messages and the applications of these devices in instructional situations. After a reorganization in 1988, it broadened its mission to include other concerns such as instructional uses of telecommunications and computer/information systems. Several of its divisions, however, still focus on the concerns of media educators and many of its state affiliates still refer to themselves as media associations.

Technology in education as instructional systems. The instructional design or instructional systems movement took shape in the 1960s and 1970s, adding another dimension to the media-and-communications view of technology in education. Systems approaches to solving educational problems originated in military and industrial training but later emerged in university research and development projects. K-12 school practices began to reflect systems approaches when university personnel began advocating them in their work with schools. These approaches were based on the belief that both human *and* nonhuman resources (teachers and media) could be parts of a system for addressing an instructional need. From this viewpoint, educational technology was seen not just as a medium for communicating instructional information, but as a systematic approach to designing, developing, and delivering instruction matched to carefully identified needs (Heinich, Molenda, Russell, & Smaldino, 1997). Resources for delivering instruction were identified only after detailed analysis of learning tasks and objectives and the kinds of instructional strategies required to teach them.

From the 1960s through the 1980s, applications of systems approaches to instruction were influenced and shaped by learning theories from educational psychology. Behaviorist theories held sway initially and cognitive theories gained influence later. Views of instructional systems in the 1990s also were influenced by popular learning theories; however, these 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 seems to be changing once again.

Just as the AECT had its origins in the media systems view of educational technology, the International Society for Performance Improvement (ISPI) grew out of the view of educational technology as a systems approach to instruction. Originally named the National Society for Programmed Instruction, the ISPI is still concerned primarily with creating and validating instructional systems.

Technology in education as vocational training tools. Another popular view of technology in education has developed from the perspective of technology as tools used in business and industry. Generally referred to as *technology education,* this view originated with industry trainers and vocational educators in the 1980s and reflects their need for technology to enhance training in specific job skills. This perspective is based on two premises. First, it holds that one important function of school learning is to prepare students for the world of work. Therefore, students need to learn about and use technology that they will encounter after graduation. For example, technology educators believe that every student should learn word processing to help them to perform in many jobs or professions. Second, technology educators believe that vocational training can be a practical means of teaching all content areas such as math, science, and language. Technology education also includes other topics such as robotics, manufacturing systems, and computer-assisted design (CAD) systems.

The organization that espouses this view is the International Technology Education Association (ITEA), formerly the American Industrial Arts Association. The ITEA has helped shape a major paradigm shift in vocational training in K-12 schools. Most schools currently are changing from industrial arts curricula centered in wood shops to technology education courses taught in labs equipped with high-technology resources such as CAD stations and robotics systems.

Technology in education as computers and computer-based systems. Another view of educational technology originated with the advent of computers in the 1950s. Business, industry, and military trainers, as well as educators in K-12 and higher education recognized the potential of computers as instructional tools. Many of these trainers and educators predicted that computer technology quickly would transform education and become the most important component of educational technology. Although instructional applications of computers did not produce the anticipated overnight success, they inspired the development of another branch of educational technology. From the time that computers came into classrooms in the 1960s until about 1990, this perspective was known as *educational computing* and encompassed both instructional and support applications of computers.

Educational computing applications originally were influenced by technical personnel such as programmers and systems analysts. By the 1970s, however, many of the same educators involved with media, audiovisual communications, and instructional systems were directing the course of research and development in educational computing. By the 1990s, these 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.*

The organization that represents this view of technology in education is the International Society for Technology in Education (ISTE), the product of a merger between two computer-oriented groups: the International Council for Computers in Education (ICCE) and the International Association for Computers in Education (IACE). IACE was known for most of its existence from 1960 until 1986 as the Association for Educational Data Systems (AEDS). A major ISTE publication, *The Computing Teacher,* reflected the original computer orientation of the organization. In 1995, it was renamed *Learning and Leading with Technology.*

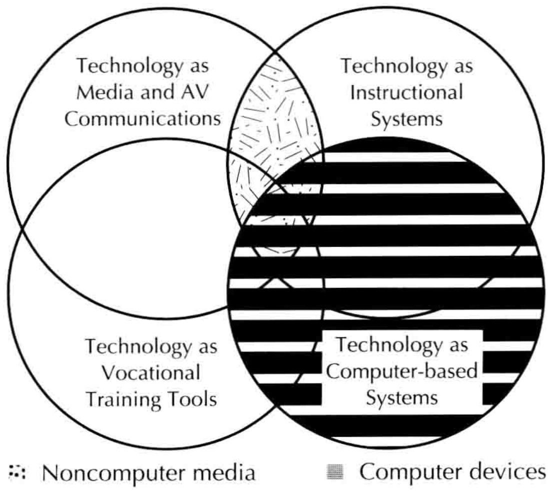
This Text's Emphasis on Technology in Education

Each of these perspectives on technology in education has made significant contributions to the current body of knowledge about processes and tools to address educational needs. But, as Saettler 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 engaged in a struggle to claim the high-profile term *educational technology.* Each seems determined to assign a definition based on the perspective and concerns of its members; each wants to be identified with and help shape the future of educational technology. However, these 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 text 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 two different areas. First, we look at learning theories based on the sciences of human behavior. Some of these theories are systems-oriented; others are based on various views of how best to foster learning. Second, this text acknowledges that many of the applications of technology focus on preparing students for future jobs by helping them acquire skills in using current tools as well as skills in "learning to learn" for tools of the future that are not yet invented—or even imagined.
- **Tools.** Although this text looks at technology tools as an overlapping combination of media, instructional systems, and computer-based support systems (see Figure 1-2), it emphasizes a subset of all these resources, focusing primarily on computers and their roles in instructional systems. There are three reasons for this focus:

1. 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. Computer systems are currently moving toward subsuming all other media within their own resources. For example, CD-ROMs and videodiscs now store images that once were shown on filmstrips and slides. Presentation software can generate overhead transparencies.

Figure 1-2 **Various Approaches to Technology in Education**



3. The complexity of computer-based systems traditionally has made it more complicated for educators to integrate various forms of software and computer-driven media 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.

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

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

In no small part, developments in computer technology have shaped the history of educational technology. Since we have learned much from our past experience that can and should help any future work in this area, this section will describe some of this history and what we have learned from it.

A Brief History of Educational Computing Activities and Resources

Since 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. This history is told in two periods: before and after the introduction of microcomputers (Niemiec & Walberg, 1989; Roblyer, 1992). (See Figure 1-3.)

Figure 1-3 **Milestones and Trends in Educational Computing Technology**

The Era Before Microcomputers	
1950	First instructional computer use: Computerized flight simulator used to train pilots at MIT
1959	First computer use in schools: IBM 650
1966	IBM offers the 1500 system: Dedicated instructional mainframe
1967	CCC offers first minicomputer-based instructional system (DEC PDP/1); Mitre Corporation offers TICCIT system
1970s	CDC offers the PLATO instructional delivery system
The Microcomputer Era and Beyond	
1977	First microcomputers enter schools
1980	Seymour Papert writes *Mindstorms*: The Logo movement begins
1980s	MECC offers microcomputer software; educational materials publishers begin courseware development and marketing
	The courseware evaluation is emphasized: MicroSIFT, EPIE, others
	The computer literacy movement begins, then wanes after 1988
1990s	Use of ILS and other networked systems increases; multimedia use and development increases
The Internet Era	
1994	Widespread use of the Internet begins
2000	Virtual reality systems and other virtual environments are emphasized

The pre-microcomputer era. Many of today's technology-oriented teachers have been using computer systems only since microcomputers came into common use, but a thriving educational computing culture predated that development by 20 years. The first documented instructional use of a computer was in 1950 with a computer-driven flight simulator used to train pilots at MIT. The first use with school children was in 1959 when an IBM 650 computer helped to teach binary arithmetic to New York City elementary school students. The intense development and research with mainframe-based computer systems in schools, colleges, and universities peaked in the early and mid-1970s with federal government funds supporting many large-scale projects. During this time, there was growing excitement and interest in computer-based instruction, also known as *computer-assisted instruction* or *CAI*. Although they used earlier technologies, each of these activities had an impact on current computer uses in education.

Mainframe and minicomputer systems by IBM, CCC, and CDC. From about 1972 to 1980, the development and marketing efforts of IBM, the Computer Curriculum Corporation (CCC), and the Control Data Corporation (CDC) dominated the educational computing field. Stanford University used the **IBM 1500 system**, the first computer system dedicated solely to instruction and research on learning, and a high-level language called *Coursewriter.* The resulting lessons were called *courseware,* or *instructional software.* This system also was the first multimedia learning station; it had a cathode ray tube (CRT) screen, earphones, a microphone, an audiotape player, and a slide projector. Until 1975, when IBM discontinued support, some 25 universities and school districts had these systems and were following Stanford's model. Stanford also developed CAI for one of the first minicomputers: **Digital Equipment Corporation's PDP-1**. Professor Patrick Suppes, the first CCC president, led an extensive research and development effort that earned him the honorary title "Grandfather of Computer-assisted Instruction." Dr. Don Bitzer, working at the University of Illinois in conjunction with CDC, initiated yet a third line of development: an instructional system called **Programmed Logic for Automatic Teaching Operations (PLATO)**. The PLATO system had a terminal with a plasma screen (argon/neon gas contained between two glass plates with wire grids running through them), a specially designed keyboard, and an authoring system similar to Coursewriter called *Tutor,* which it used to develop tutorial lessons and complete courses rather than just drill and practice lessons. CDC's president, Dr. William Norris, had an almost messianic belief that PLATO would revolutionize classroom practice (Norris, 1977); he channeled significant funding and personnel into development of PLATO between 1965 and 1980.

Other major products: TICCIT, PLAN, and IPI. Parallel lines of development took place at Brigham Young University (BYU) and the University of Pittsburgh. At BYU, Dr. Victor Bunderson and Dr. Dexter Fletcher added color television to a computer learning station and developed Time-shared Interactive Computer-Controlled Information Television (TICCIT). Other products, such as the Program for Learning in Accordance with Needs (PLAN) developed at the American Institutes for Research, and the Individually Prescribed Instruction (IPI) system at the University of Pittsburgh, focused on using computer systems to support mastery learning models with computer-managed instruction (CMI) systems.

University time-sharing systems. During the 1960s and 1970s, as CAI and CMI development was taking place, a thriving computer culture developed at 22 universities around the country where faculty and students used mainframe systems to teach programming, develop programs and utilities, and share them among members of the academic community. The first meeting of these groups in Iowa City in 1979 was the National Education Computing Conference (NECC), now the largest educational technology conference in the country.

Administrative computing systems. While interest in instructional applications grew, educational organizations worked to computerize more and more of their administrative activities (e.g., student and staff records, attendance, report cards). Since mainframe computer systems were both expensive and technically complex, school district offices, rather than with schools or individual teachers, controlled both instructional and administrative computer hardware and applications. Data-processing specialists administered most of these systems. This lack of local control was not always popular with teachers, who neither understood the computer systems that delivered the instruction nor had much say in the curriculum developed for them. By the late 1970s, interest in CAI seemed to decline as it became clear that computers could not revolutionize classrooms in the same way that they were changing business offices in post–World War II America; this kind of revolution was neither feasible nor desirable in education.

The microcomputer revolution in education. The first microcomputers came into schools in 1977 and the focus rapidly shifted from mainframes to desktop microcomputer systems. The introduction of these locally controlled resources also transformed the computer's role in education. Computer resources and their instructional applications were no longer managed by large companies or school district offices. Classroom teachers could decide what they wanted to do with computers. Even some administrative applications began to migrate to school-based computers, much to the dismay of personnel in district data-processing centers. Microcomputers made school-based management even more feasible.

The software publishing/courseware evaluation movement. Before microcomputers, courseware came primarily from hardware manufacturers such as IBM and CDC, software systems companies like CCC, and university development projects. As microcomputers gained popularity, a new software market for education driven primarily by teachers emerged. The nonprofit Minnesota Educational Computing Consortium (MECC), with funding from the National Science Foundation, developed much of its original instructional software on mainframes but later transferred these programs to microcomputers and, for a time, became the largest single provider of courseware. Other major software publishing companies quickly jumped into the courseware development market, and a plethora of small companies, many of them cottage industries, were also organized. As the dominance of mainframes ended, teachers learned that having lessons on microcomputers did not guarantee quality or usefulness. Activities like the Northwest Regional Educational Laboratory's *MicroSIFT* project and the Educational Products Information Exchange (EPIE) as well as those by professional organizations, magazines, and journals sprang up to evaluate courseware. So many reviews were produced, *other* organizations began to compile and summarize reviews. Most of these groups eventually went out of business as courseware evaluation became less essential and school districts developed committees to select courseware.

Courseware authoring activities. As teachers began to clamor for more input into the design of courseware, some companies saw another potential market for tools to let educators develop their own courseware. These *authoring systems* were the predecessors of modern tools such as HyperCard and Linkway. Some authoring systems were more like high-level languages (PILOT and SuperPILOT), while others prompted systems that allowed developers to choose from menus of options (GENIS, PASS). For a time, teacher-developed software became popular, but interest faded as teachers realized how much time, expertise, and work had to be invested to develop courseware that would prove more useful than what they could buy.

The computer literacy movement. From the beginning, teachers wanted students to learn *about* (as well as with) computers, an activity that came to be called *computer literacy.* The term is thought to have been coined by educational computing pioneer Dr. Arthur Luehrmann (Roblyer, 1992), who originally believed that computer literacy was defined as programming skills and use of tools such as word processing. Later, it became associated with a variety of skills. A popular fear in the 1980s was that students who were not "computer literate" would be left behind academically, further widening the gap between the advantaged and disadvantaged (Molnar, 1978). By 1985, computer literacy skills began to appear in required curricula around the country; but by around 1990, they were dropped as educators began to feel that computer literacy could not be linked to any specific set of skills. However, the late 1990s saw renewed interest in this topic as districts began requiring "technology literacy" skills (North Carolina, 1999).

Logo and the problem-solving movement. From 1980 until about 1987, Logo had a profound influence on instructional computing; Logo-based products, activities, and research dominated the field. Logo was developed and promoted as a programming language for young children by Seymour Papert, an MIT mathematics professor (Cuban, 1986). Through Papert's prolific writings and speeches, Logo also became a challenge to traditional instructional methods and to the computer uses that had supported them (drill and practice, tutorial uses). Papert based his philosophy of computer use on his interpretation of the work of his mentor, developmental theorist Jean Piaget. In his popular book *Mindstorms,* Papert proposed that child-directed exploration was better than teacher-directed instruction and that Logo-based projects could be the basis for such exploration. Versions of the Logo language were developed, derivative products were marketed (Logowriter, LegoLogo), and Logo assumed the characteristics of a craze: Logo clubs, user groups, and T-shirts filled the schools. Although research showed that the applications Papert proposed could be useful in some contexts, by 1985 educators said that "Logo promised more than it has delivered" (Papert, 1986, p. 46) and interest waned. Logo is still in use, but Logo's main contribution may have been its example of how technology could be used to revise and restructure educational methods.

Integrated learning systems (ILSs) and other networked systems. ILSs were a mirror image of the types of systems first developed and marketed in the 1970s, some even using curricula derived from those developed by Stanford's Pat Suppes. ILSs came about because both school districts and software companies realized that one of the most common applications of microcomputers—and one with strong validation by research—was instruction and practice in basic skills. They saw that microcomputers networked to a central server could provide this instruction more cost-effectively than a system using disks on standalone microcomputers. ILSs also could track and report data on student progress and allow quick access to various courseware types in one location. In 1991, when curriculum trends moved toward less structured and teacher-directed methods, companies began to market other networked systems sometimes called *"multimedia learning systems," "integrated technology systems,"* or *"open learning systems"* (Hill, 1993, p. 29). But, since there was no universally accepted alternative name for these less-structured systems, any networked instructional delivery system usually is called an ILS. By any name, all systems networked with a central server mark a significant movement away from single computer systems under the control of individual teachers and back toward more centralized control of instructional computing resources.

The birth of the World Wide Web. As exciting and challenging as they were, the first 30 years of educational computing technology seem mundane compared to what occurred about five years before the new millennium. The emergence of the Internet has been likened to "fire ... more important than the invention of movable type" (Remnick, 1997, p. 214). A text-based version of the Internet was used by university educators since the 1980s to exchange information. In 1994, the program Mosaic made it possible to see information as a combination of pictures and text; and popular interest was sparked in a way no one had predicted. Teachers joined the ranks of people in all areas of society in recognizing the power of the Internet: ready access to people and information, the ability to send and receive multimedia displays, and an increasingly realistic simulation of "being there." Educators who had never before been interested in technology began to envision the possibilities. The *Information Superhighway* became an expressway for education.

What Have We Learned from the Past?

A history of educational technology is interesting, but useless unless we apply the information to future decisions and actions. What have we learned from some 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.** Educators and parents tend to look to technology for answers to education's most difficult problems, but great expectations for products like 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. 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 the question: What specific needs do my students and I have that (any given) resources can help meet?
- **Computer literacy/technological literacy is a moving target.** Experience has shown that there is no concise, agreed-upon definition for *"computer literacy"* or *"technological literacy."* The skills that define these terms vary according to student needs and age levels as well as the focus of the groups defining them. Further, we know now that, as technology evolves, the skills students will require for the future tend to change, often dramatically and quickly. As they did for a period of time in the 1980s, school districts and state departments again are beginning to add technology skills to their required curriculum, along with reading, writing, and mathematics. But the skills they are adding are far different now in scope and purpose from those of just 10 years ago, and this trend of technology skills as a moving target seems likely to continue indefinitely.
- **Computer literacy/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* 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 content area skills that display obvious need for improvement in our current system of education, for example, reading, writing, and mathematics skills; research and information-gathering; and problem solving and analysis.
- **Standalone computers and networked computers have benefits and limitations.** The pendulum of emphasis in education has swung from networked systems to standalone systems, then back to networked systems. Yet no single delivery system or configuration has proven ideal for all situations. Networks make it more feasible to standardize materials across classrooms, schools, or districts; allow easier tracking of student usage and progress; and facilitate collaboration among teachers and students. Standalone computers offer more individual and/or local control and are more flexible to schedule and access. Each type of system will continue to be needed.
- **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 most integration strategies. In the past, publishers, school or district developers, or personnel in funded projects have provided this assistance, and 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. As we write this book, procedures for human cloning are within reach and genetic engineering is increasingly feasible. In education, we can simulate face-to-face communication to an increasingly realistic degree. All 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, sometimes 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, any "technological guru" who gives a glib rationale for new methods can lead a new movement in edu-

cation. When dramatic improvements 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 dressing. In short, teachers must be as informed and analytical as they want their students to become.

- **Teachers always will be important.** 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 *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)" (Naisbitt, 1984, p. 35). Also, 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 limitations. In an increasingly technological society, we need more teachers who are both "technology-savvy" and child-centered.

Why Use Technology? Developing a Sound Rationale

The history of educational technology also teaches us the importance of the "why?" question. Many educators, parents, and students believe the reasons for using technology seem so obvious that everyone should recognize them. Their common sense rationale is based on two major beliefs: (1) technology is everywhere and therefore, should be in education and (2) research has shown how and where computer-based methods are effective. Both of these commonly held beliefs have some validity and both provide rationales for using technology—at least as far as they go. But we also need answers to some practical questions:

1. Should technology take over most or all of a teacher's role? If not, how should it fit in with what teachers already do?
2. Should schools rely on computers at all levels, for all students, or for all topics? If not, which levels, students, or topics suit computer-based methods?
3. Does some reliable information suggest specific benefits of using technology in certain ways?

To justify the expensive and time-consuming task of integrating technology into education, teachers must identify specific contributions that technology can and should make to an improved education system. Funding agencies, for example, can reasonably ask why a school should choose a technology-based resource or method over another path to reach its desired goals. As Soloman (1995) said, "It's the vision thing ... we first have to ask 'What do we need technology for?' We must create our vision, define technology's role in our schools, then plan for its use" (p. 66). The rationale we choose for using technology will guide our goals and help identify the skills and resources needed to accomplish these goals.

Problems with research-based justifications for educational technology. Many educators look to educational research for evidence of technology's present and potential benefits. Although technology (especially computers) has been in use in education since the 1950s, research results have not made a strong case for its impact on teaching and learning. In general, the number and quality of studies on educational impact have been disappointing (Roblyer, Castine, & King, 1988). But 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. After considerable research in this area, Clark concluded that most such studies suffered from confounding variables. The studies attempted to show a greater impact on achievement of one method over the other without controlling for other factors such as instructional methods, curriculum contents, or novelty. These differences could either increase or decrease achievement. Clark (1985) exhorted educators to "avoid rationalizing computer purchases by referencing the achievement gains" (p. 259) in such studies. Kozma (1991, 1994) responded to these challenges by proposing that research should look at technology not as a medium to deliver information but in the context of "the learner actively collaborating with the medium to construct knowledge" (p. 179). In light of the lack of consensus, however, it seems best to follow Clark's advice to refrain from using past reviews of research to justify investments in technology. However, several promising lines of research and several aspects of technology use (shown in Figure 1-4) offer elements of a rationale for continuing or expanding the use of technology in education.

Justifying technology use: The case for motivation. Motivating students to learn, to enjoy learning, and to want to learn more has assumed greater importance in recent years as we recognize strong correlations between dropping out of school and undesirable outcomes such as criminal activity. The drive to keep students in school is an urgent national priority. Technology has an important role to play in achieving this goal. Kozma and Croninger (1992)