



Learning with Technology

**Evidence that technology can,
and does, support learning.**

A white paper prepared
for Cable in the Classroom

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Executive Summary

“We’ve wired the schools — now what?” This question resonates with educators, and troubles them at the same time. After countless local and national efforts have boosted the infrastructure of our schools, the significant issues now arise. Should we continue to pump money into educational technology for our schools? Do computers really help students learn? How can students and teachers best learn from the World Wide Web and its content?

These questions are not new, nor unique to the dawn of Internet-connected schools. Earlier technologies, from textbook and illustration to film, television, and multimedia computer, have prompted similar ponderings. If technology is to have a significant role in schools, we need assurance that it works. More emphatically, we need confidence that use of educational technology results in learning.

Research, both historical and contemporary, suggests that technology-based instruction can and does result in learning. Witness these examples of television, multimedia, and computer technologies delivering content to support learning:

- Watching the television program *Blue’s Clues* has strong effects on developing preschool viewers’ flexible thinking, problem solving, and prosocial behaviors (Bryant, Mullikin, McCollum, Ralstin, Raney, Miron, et al., 1998).
- Court TV’s *Choices and Consequences* program reduced middle school students’ verbal aggression — including tendencies to tease, swear at, and argue with others (Wilson, Linz, Federman, Smith, Paul, Nathanson, et al., 1999).
- Viewing *Sesame Street* was positively associated with subsequent performance in reading, mathematics, vocabulary, and school readiness (Wright, Huston, and Kotler, 2001).
- A “recontact” study with a sample of 15- to 20-year-olds found that those who had been frequent viewers of *Sesame Street* at age 5 had significantly better grades in English, science, and mathematics; read more books for pleasure; and had higher motivation to achievement (Huston, Anderson, Wright, Linebarger, and Schmitt, 2001).
- Students show greater achievement on standardized tests after using computers for mathematics problem solving (Clouse, 1991–92; Phillips and Soule, 1992).
- Remedial reading students using computer reading games for reinforcement and remediation showed significant knowledge gains and improved attitudes toward reading (Arroyo, 1992; Nixon, 1992).
- Learning-disabled (LD) students using computer simulations score significantly higher than traditionally taught students (both LD and non-LD) on recall of basic information and problem-solving skills (Woodward, Carnine, and Gersten, 1988).
- Use of educational technologies accounts for at least 11 percent of the total variance in the basic skills achievement gain scores of fifth-grade students, as measured in a 10-year West Virginia statewide study (Mann, Shakeshaft, Becker, and Kottkamp, 1999).

This evidence is but a taste of the rich and compelling research studies that demonstrate students learning from technology. Regardless of the means—be it television or computer, or even computer-delivered streaming video—when content is presented with purpose, the student can experience the content and attach the new information to that which is already known. This process of creating associations and making meaning is part of learning. Educational technologies expand our access to new information and support our efforts to make meaning.

Yet, as there is evidence that technology supports the making of new connections and, therefore, learning, there is complementary evidence that “no learning” can also result. Poorly designed programs that lack an instructional foundation; casual, purposeless use of technology in the classroom; and lack of alignment between desired learning outcomes and the application of educational technology all threaten the success of any learning-by-technology endeavor. Successful technology-based learning relies heavily on a context for use; classroom teachers play a significant role in facilitating student learning and aligning educational technology with content from complementary sources.

In today’s world, it isn’t *what* you know but rather what you *can* know —and how fast you can know something new. Technology is a non-negotiable tool in the process and a competitive advantage in terms of the speed at which we access that which is new.

In this way, technology brings new opportunities to access information, to create rich technology-based environments where students experience new and challenging things, and to connect students with new and different people, places, and things. Technology can take us to places we have never been nor are likely to ever go. Technology can connect us with people around the world who offer different perspectives and experiences. These opportunities will result in many types of learning. It is up to classroom teachers, instructional designers, and program developers — essentially every individual involved in education —to ensure that these technology-facilitated opportunities benefit learning and every child’s future.

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Background

On September 29, 1989, leaders of the cable industry—38 CEOs in all—sat together to found the Cable Alliance for Education, a non-profit foundation with a mission to support excellent education work across the industry. It was indeed an alliance—a national consortium of cable operators and networks—aimed at serving teachers and students in K-12 schools across the country, and based on the premise that powerful technology and rich content can help make learning happen.

The cable industry's unflinching commitment to education has continued from that day to this. And this Alliance for Education, renamed Cable in the Classroom, now stands at the threshold of its own renaissance. Our own revitalization began with fresh perspective and a simple question: given the last decade's developments in learning theory and technology, and given technology's pervasiveness in schools, how can we reshape and refocus our work in a way that will benefit learners to the greatest extent possible?

We are led by an educational philosophy, which holds that every student and teacher has a right to five elements essential to a good education in the 21st century:

- Visionary and sensible use of technology to extend learning
- Engagement with deep, rich content
- Membership in a meaningful community of learners
- Excellent teaching
- Support of parents and other adults.

As the founders of Cable in the Classroom were in 1989, we are still compelled by the explosion of media and developing technologies and their power to affect learning. And as always, we are driven by the absolute truth that good teaching and good learning are the most potent forces on earth. Without them, the best educational technology lies dormant.

While we will undertake original research down the line, it seems important to set out with a fresh analytical look at the power that media and technology bring to the learning process. Dr. James Marshall, a researcher and educational technologist now with San Diego State University's Department of Educational Technology, provides us with this lively and practical research base. It is an excellent foundation on which to build Cable in the Classroom's future work.

Now that schools are wired, the remaining challenge is to put those wires to work, by extending the development of the highest caliber content and by preparing teachers to integrate into the exciting work already underway in their classrooms. This report takes a lengthy stride in that direction, by rounding up the research that shows how technology enhances learning and underscoring the vital role teachers play in making technology part of the educational experience. Armed with this knowledge, good teachers can do what they do best – use their insight into individual learning styles and needs to select the technology and content that will ensure a positive and successful learning experience for students.

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Foreword

After 30 years on the Columbia University faculty, I now spend all my time examining the learning outcomes available from technology. Despite that concentration, I still benefited from Marshall's close analysis of how technology advances learning. At a time when landmark federal legislation—the “No Child Left Behind” Act of 2002—makes 110 references to “evidence-based” decisions about teaching and learning, this review of the empirical data is particularly helpful.

Technology is anything that extends human capability. Technology got started when chimpanzees concluded that a stick in the fist was more persuasive than an empty hand. People continue to debate the merits of learning technology in policy forums and in practical settings. Marshall's review of the dynamics beneath the uneven trajectory of classroom adoption of technology is apt, particularly when coupled with the evidence he assembles about the positive contributions of TV. Like any technology, TV can be turned to purposes that are bad, indifferent, or good. Marshall does everyone a service in recalling our attention to the positive gains from this ubiquitous medium.

Whatever the outcomes of adult pondering, we are fortunate to be led by little children. Consider the dominance of technology platforms in the responses of 6- to 11-year-olds to the question, “What makes a new subject in school most interesting to me?”

- Internet 34%
- TV program 24%
- Teacher 26%
- Textbook 12%

Source: USA Today

Finally, it is important to keep in mind that Marshall is reviewing the outcomes from a moving target. I believe that there are three irrevocable forces in the world: democracy, markets, and technology. We will only have more technology and the potential for its wholesome uses will only increase. The example of West Virginia is instructive. As measured by gains in its students' test scores, the entire state of West Virginia moved from 33rd worst to 11th best among the American states. That unprecedented whole-state systemic transformation was begun in 1989 with computer-related technology, and that time was a digital dark age for hardware and software compared with the current assets. And still they learned!

And consider the future. Ray Kurzweil, who among other things invented music synthesis, has analyzed the computing firepower available from a \$1,000 purchase at a computer store. In 2000, \$1,000 bought the equivalent of an insect's calculating capability; in 2010, it will buy a mouse's capability; in 2025, it will buy the functional equivalent of one human being's capability; and in 2060, it will purchase the calculating capability of the then-extant, entire human race, in series [Ray Kurzweil, *The Age of the Spiritual Machine*].

In *How We Learn*, John Dewey concluded, “We practically never teach anything by direct instruction but rather by the creation of settings.” Dewey was right, but in the 1930s he lacked what we now have: the ability, through technology, to create powerful settings for learning.

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Introduction

Ask a child to picture “learning,” and the classroom and the teacher naturally come to mind. Classrooms, teachers, desks, paper, and pencil are all part of the traditional learning environment. The past century has supplemented and enriched this traditional environment with new ways of presenting content for learning. Today, opportunities abound for learning through multiple media—from pictures, overhead projectors, and filmstrips to moving pictures, videos, and computers. And yet, do these educational technologies and the content that they provide result in learning? **Extensive research into learning with technology provides conclusive evidence that people can, and do, learn from educational technologies.**

Our exploration of educational technology begins with “Highlights in the Evolution of Educational Technology,” an abbreviated history of technological developments across the 20th century. We limit the focus to technologies employed for educative pursuits. **Historical evidence suggests that technology can, and did, teach.**

“The Process of Learning: A Learning Primer” provides a buffet of theories that address how people learn. We discuss learning as both a neurological process and a result of interacting with the environment around us. We highlight learning as a struggle to make meaning by making connections. Finally, we introduce the concept of multimedia and explore its use as a learning environment. We conclude by discussing the requisite attributes of multimedia if learning is to result. **Research that describes the process of learning, including the linking of existing knowledge to newly acquired content, suggests that technology can, and does, facilitate learning. Technology can present new knowledge and support the task of making connections between what is known and new knowledge.**

While the preceding section highlights the process of learning, “Research-Based Evidence: Learning with Educational Technology” brings together technology and content with rich examples of educational technology programs and the results they have attained. Results from programs including *Sesame Street*, *Blue’s Clues*, Court TV’s *Choices and Consequences*, and Apple’s Classrooms of Tomorrow and a handful of other studies provide conclusive evidence that learning can result. Further, these studies present examples of the types of learning that can result from use of educational technology. This section also addresses the classroom context upon which educational technology is often dependent. Here, we discuss the important role played by the classroom teacher—the individual who keeps the gate to classroom use. **More than 50 research studies addressing voice, video, and computer-based learning provide conclusive evidence that students can, and do, learn from educational technologies.**

The final section, “View from the Future: Emerging Technologies,” casts a quick glance forward by describing cutting-edge technologies. We identify broadband connectivity as critical to the success of emergent technologies (for example, webcasts, videoconferencing, and wireless technologies). We also imagine the future these evolving technologies may prescribe and their exciting potential for educational applications. **The future is rife with technology that enables new connections to people, places, and things. These experiences will continue to foster new knowledge for students using educational technologies.**

Although this paper offers research and examples that suggest that educational technologies are effective tools for learning, a word of caution is in order. As with most research endeavors, these studies have limitations. Learning is a complex process, as is studying how and whether people learn. It is impossible to identify and control every variable that affects learning in order to make a statement that one particular treatment (e.g., Internet-based instruction) results in learning.

With that cautionary statement aside, the reader should know that significant and compelling evidence points to technology as a successful means for learning. This paper presents classic studies that have stood the test of time alongside contemporary research that reinforces and extends the early findings. Together, the research highlights learning accomplished through both television- and computer-based technologies. The studies presented here offer convincing evidence that technology can, and does, make powerful contributions to learning.

Highlights in the Evolution of Educational Technology

The medium is the message. Marshall McLuhan, 1964

The term “educational technology” often brings to mind the hard technologies—the tangible “stuff”—used for teaching and presenting content—in other words, the medium. From simple graphical illustrations and projectors for film and filmstrip alike, to the more complex Internet-surfing computers, these tools are central to the educational technology equation. These devices share a rich history; their development and evolution into the 21st century are punctuated with applications to traditional and nontraditional learning endeavors.

Although this early history emphasizes hard technologies, these tools would be an unsuccessful means for learning without the content they deliver. As we review selective moments in history, note the shift from interest in the technology to a focus on the content the technology provides, suggesting that the media *may not* be the only message.

The Birth of Technology-Based Learning: Turn-of-the-Century Media Centers

Although use of visual illustrations for learning can be identified long before the 20th century, the birth of technology-based learning coincides with audiovisual media being introduced into U.S. schools in the early 1900s (Reiser, 1987). In some cases, technology-based learning entered educational institutions through “school museums.” These forerunners to today’s school media center served as repositories for visual instruction. They distributed portable museum exhibits, stereographs, slides, films, study prints, charts, and other materials designed to enhance instruction (Saettler, 1968). References to “visual education” can be found as early as 1908, when the Keystone View Company’s publication *Visual Education* guided teachers’ use of lantern slides and stereographs (Saettler, 1968).

In 1910, the first catalog of instructional films appeared (Reiser, 1987) and, in that same year, the public school system of Rochester, New York, became the first adopter of films for instructional use. In 1913, Thomas Edison proclaimed:

Books will soon be obsolete in the schools. . . . It is possible to teach every branch of human knowledge through the motion picture. Our school system will be completely changed in the next 10 years (Saettler, 1968, p. 68).

Although Edison’s vision for dramatic change did not come to pass, visual instruction coursework did become common practice in 20 different teacher-training institutions. During this time, 12 of the larger K–12 school systems established bureaus of visual education (Reiser, 1987), and five journals focusing on visual education began publication (Saettler, 1968).

The late 1920s and the 1930s saw growth and expansion of visual education pursuits. Advances in technology, including radio broadcasting, sound recording, and sound-motion pictures, all fueled the growing interest in visual instruction (Finn, 1972; McCluskey, 1981).

World War II Thrusts Educational Technology Forward

With World War II came significant advances in educational technology. The bombing of Pearl Harbor caught the United States by surprise and forced the country into war. Thousands of soldiers needed training in basic combat and survival skills. The Division of Visual Aids for War Training in the U. S. Office of Education rose to meet this World War II challenge. The division designed and produced 457 sound-motion pictures, 457 instructor manuals, and 432 silent filmstrips (Saettler, 1968). The U.S. government purchased 55,000 film projectors to implement the instructional technology and spent \$1 billion to develop and distribute training films (Olsen and Bass, 1982).

These training efforts proved that technology could teach—a fact echoed by enemy forces who came to respect the power of technology-based training. In 1945, after the German surrender, the German Chief of General Staff remarked:

We had everything calculated perfectly except the speed with which America was able to train its people. Our major miscalculation was in underestimating their quick and complete mastery of film education (cited in Olsen and Bass, 1982, p. 33).

Success during World War II heightened interest in audiovisual instruction, especially school-based use of audiovisual devices (Finn, 1972; Olsen and Bass, 1982). With evidence that past technology-based learning efforts had proved successful, attention shifted to answering the question “Why?” Research studies sought to “identify how various features, or attributes, of audiovisual materials affected learning; the goal being to identify those attributes that would facilitate learning in given situations” (Reiser, 1987, p. 15).

From Instructional Television to Educational Television

With the 1950s came increased interest in television as a tool for learning. Two factors influenced this increase: (1) the birth of educational television stations and (2) significant funding for educational television provided by the Ford Foundation.

The Federal Communications Commission set aside 242 channels for educational use. This resulted in the development of many educational television stations that presented instructional programs and that would eventually become today’s public television stations. Hezel (1980) described:

The teaching role has been ascribed to public broadcasting since its origins. Especially prior to the 1960s, educational broadcasting was seen as a quick, efficient, inexpensive means of satisfying the nation’s instructional needs (p. 173).

Early studies evaluating the efficacy of instructional television suggested that student achievement via classroom television was just as successful as that via traditional face-to-face instruction. Parsons’ (1957) research revealed only borderline differences in achievement; however, LePore and Wilson (1958) offered research showing that learning by television compared favorably with conventional instruction.

Intrigued by the possibilities, the Ford Foundation provided monetary support to the burgeoning educational television movement. Gordon (1970) estimates that the foundation and its agencies spent more than \$170 million on educational television during the 1950s and 1960s. Ford funded diverse applications of educational television, including outfitting an entire Maryland school district with closed-circuit television to deliver instruction in all major subject areas and

grade levels. Ford also funded the Midwest Program on Airborne Television Instruction, which transmitted televised lessons from airplanes to schools in six mid-western states (Reiser, 1987).

Yet, by the mid-1960s, interest in educational television waned. Many of the funded projects ceased to exist. Mediocrity in the instructional quality of these programs was chief among the reasons for their downfall; “many of them did little more than present a teacher delivering a lecture” (Reiser, 1987, p. 17). By 1963, Ford refocused its financial support to public television pursuits, rather than in-school applications; when funding ceased, school districts discontinued their instructional television projects.

The downfall of educational television prompted people to question the effectiveness of the materials developed and the presentation technologies. This questioning led the 1967 Carnegie Commission on Higher Education to conclude that:

. . . the role played in formal education by instructional television has been on the whole a small one. . . . With minor exceptions, the total disappearance of instructional television would leave the educational system fundamentally unchanged (pp. 80–81).

Many reasons are cited for the downfall of instructional television. Teacher resistance to television in the classroom, the expense of the television systems, and the inability of television alone to meet the various conditions for student learning are among reasons cited to explain the failure of this medium (Gordon, 1970; Tyler, 1975).

Taken together, these justifications for instructional television’s downfall support a basic point: The technology was trying to replicate classroom teaching. Rather than enhancing and extending the good things already happening in the traditional classroom, instructional television mirrored classroom teaching practices, replacing the classroom teacher with a television version.

About this time, educational television entered the scene and grasped the opportunity to supplement good teaching practices with compelling programs and content. Programs like *Sesame Street* brought content to life, reinforcing and extending that which was taught to children in schools across the nation. The 1980s saw

the birth of Cable in the Classroom, which made educational television available and accessible to teachers. The delivered programs spanned content areas, enabling teachers to integrate the television-delivered content into their curriculum with purpose. The result was useful technology that supported and extended the content that teachers were required to teach.

Beyond Television to Interactivity

While interest in instructional television slowed and educational television pushed forward, excitement about computer-based learning was gathering momentum. Computer-based learning offered the promise of individualized instruction by presenting unique instruction based upon each learner's unique needs. In the 1950s, researchers at IBM accomplished much of the early work in computer-assisted instruction; IBM designed the first such program used in public schools (Baker, 1978). Large and costly, these mainframe computers were seldom affordable, and seldom seen, in schools.

In the 1960s, a collaborative effort between the National Science Foundation, the University of Illinois, and Control Data Corporation produced PLATO (Programmed Logic for Automatic Teaching Operations). PLATO, originally limited to mainframe computers, continues to be used today in many universities and school systems around the country. PLATO's goal was to automate individual instruction and, over the seven-year developmental stage, to examine the utility and feasibility of the computer-based teaching system.

The Personal Computer

One of the most significant jumps forward in educational technology has to be the development of the microcomputer (today's personal computer) in the early 1970s. Less costly and smaller than mainframe computers, personal computers could still perform most of the instructional operations of their mainframe siblings (Reiser, 1987). Of particular relevance to K–12 education was the appearance of Apple Computer, Inc., in 1976 and the marketing of its first computer, the Apple I. Apple established a significant following among educators by discounting and donating hardware to schools and developing instructional software targeted to the K–12 market.

Computers Meet Resistance in Classroom Use

The relationship between the personal computer and the K–12 classroom continued to grow throughout the 1970s and 1980s. Early barriers to technology-based learning in the classroom focused on access. The educational system lacked the necessary funds to provide computers for every classroom. To mediate this barrier, many schools established computer labs.

Even with access to hardware, barriers to school use remained. Teachers hesitated to use the machines. Drill and practice educational software programs were the norm; opportunities for students to engage in problem solving and active construction of knowledge were few. The Integrated Learning Systems of the 1970s and 1980s assessed a student's current performance and then presented computer-based lessons matched to each student's level of performance. As the student progressed, the computer adjusted the difficulty of the lessons. These systems directly addressed any teacher resistance to use simply by removing the teacher from the equation. Lack of prerequisite skills and knowledge to successfully operate the technology, and fears that embracing technology meant working their way out of jobs, provided additional ammunition for teacher resistance.

The Internet Arrives

The arrival of the Internet in the 1990s added fuel to the push for teachers to integrate technology into the classroom. With the Internet came unlimited amounts of content and new demands on teachers. If teachers were to use the Internet for learning, they needed to take an active role in organizing technology-based learning, rather than simply sitting back and letting educational software entertain computer users. Teachers needed to access and evaluate content, and then design instructional activities that integrated Internet content with learning objectives and traditional classroom materials. The Internet continues to challenge teachers. Not only must they be adept at locating good content, but they must skillfully align that content with teaching outcomes. They must craft learning activities that exploit the best of each instructional strategy—classroom-presented and technology-delivered alike.

The Bottom Line: Content Reigns Supreme

Today, educational technologies are an expected, and often demanded, component of the modern classroom. The relationship shared by teacher, student, and educational technology is one that has seen both success and failure, but certainly is not lacking in passion.

The rise of the Internet, just like the success of educational films during World War II, has prompted us to refocus questions about the content delivered by the technology. There is little doubt that technology can facilitate learning. We learn through that which we experience. Yet, the success of learning relies largely upon the quality of the presented content and the instructional strategies employed in that presentation. Witness the failure of early educational television because of over-reliance on talking heads. Witness the large variance in Internet-surfing skill, significantly influenced by ability to differentiate between useful and less useful information.

Teacher resistance to technology use has affected technology-based learning, and well-designed, technology-delivered content remains unused. Today's teacher must be a participating learner in the classroom, someone who takes risks alongside his or her students—sometimes without knowledge of the “correct” answer. Collaborative technology, including multimedia programs and various applications of the Internet, is pushing teachers in this direction.

Summary

The history of educational technology is rich with examples of developing technology and the content it delivers. Early assessments of its potential placed high expectations on educational technology. Thomas Edison predicted books would be obsolete in schools and the motion picture would be the preferred teaching medium.

Though Edison's prediction failed to come true, results of educational technology were realized:

- Institutions of higher education trained teachers to use visual instruction in their classrooms.
- The government pumped \$1 billion into training soldiers with instructional films during World War II. German forces

remarked that their one miscalculation was the rate at which U.S. civilians could be turned into soldiers via film education.

- The Federal Communications Commission dedicated 242 channels for educational television programming, believing television to be a quick and inexpensive means for delivering instruction. Today, many channels remain as members of the Corporation for Public Broadcasting.
- Instructional television received mixed reviews. Some research suggested that students learn just as well from television as face-to-face instruction. In cases where learning failed to materialize, poor program design, extensive use of “talking heads” that simply relayed content, and general teacher resistance to using television in the classroom were each identified as probable causes for instructional television's shortcomings.
- Educational television replaced instructional television. Rather than replicating the traditional classroom and teacher via television, educational television provided rich and vivid programming that teachers could integrate into their typical classroom practices. These programs enhanced the “toolkit” of instructional strategies upon which teachers could draw when delivering instruction.
- IBM researchers explored the potential of computer-based learning. The arrival of the personal computer lowered the cost of the technology and extended the reach. Software, though mostly drill and practice, helped people of all ages learn new things — from multiplication tables to keyboarding skills.
- The Internet's proliferation continues to extend our reach with access to new information and knowledge. Today, we are faced with challenges of information overload and differentiation between credible and less credible sources.

This history provides evidence that learning can result from the use of educational technologies. Early use of these “tools of learning” provided tangible results and prompted interest in the increasing potential for learning by technology.

The Process of Learning: A Learning Primer

**I believe television is going to be the test of the modern world. In this new opportunity to see beyond the range of our vision, we shall either discover an unbearable disturbance of the general peace or a saving radiance in the sky. We shall stand or fall by television – of that I am sure.
E.B. White, 1938**

Unbearable disturbance or saving radiance? Although E.B. White may have never imagined television entering our classrooms to educate, query educators about classroom use of technology and you will uncover evidence to support either of White's assertions. Educators who hold the belief that technology supports learning use educational technologies. Those who lack such beliefs may consider it an unbearable disturbance.

Today's movement to hold teachers accountable for student learning places considerable pressure on teachers to ensure increases in each student's knowledge and abilities. Teachers need proof that multimedia experiences can support increases in knowledge—powerful increases if employed thoughtfully and with purpose. Such proof begins with understanding how people learn and how this process of learning is a natural match to the content that educational technologies can present.

The Biological Basis of Learning

To the neuroscientist, learning and memory are so intricately entwined that you cannot discuss one without the other. Forming lasting memories has long been accepted as an essential part of the learning process. The process starts with some kind of stimulus to the brain cells—it could be an internal thought, such as a brainstorm, or an external event, such as television viewing. In his 1998 book, *Teaching with the Brain in Mind*, Eric Jensen describes how this process occurs in the brain: “[a] cell is electrically stimulated repeatedly so that it excites a nearby cell. If a weaker stimulus is then applied to the neighboring cell a short time later, the cell's ability to get excited is enhanced” (p. 14).

As we learn something new, some brain cells (specifically, neurons) grow by way of dendritic branching. This results in brain cells making more and more connections. Jensen further explains this process, known as brain plasticity:

[W]hen we say cells connect with other cells, we really mean that they are in such close proximity that the synapse (spaces between the cells) is easily and almost effortlessly “used” over and over again. New synapses usually appear after learning (p. 14).

These connections, or neural networks, become stronger the more often they are used. Hanneke Van Mier and Steve Peterson, researchers at Washington University School of Medicine, found evidence of this phenomenon in functional imaging scans of the brain. Time-lapse images revealed that while many areas of the brain “light up” when performing a new task, the brain lights up less and is used less the better the task is learned (Jensen, 1998).

Marilee Sprenger (1999), in her book *Learning and Memory: The Brain in Action*, explains this process by comparing it to creating a path in the woods. “The first time you create a path, it is rough and overgrown. The next time you use it, it's easier to travel because you have previously walked over the weeds and moved the obstacles. . . . In a similar fashion, the neural networks get more efficient, and messages travel more quickly.”

Changes in the Brain Prompted by Learning Environments

Learning changes the brain anatomically; with each new stimulation, experience, and behavior, it can rewire itself. Because we are all raised in different environments with different experiences, each brain is unique. Even identical twins do not have identical brains.

In the 1960s, various researchers showed that the environment can substantially influence the architecture of the brain. Marian Diamond (1967), a neuroanatomist at the University of California at Berkeley, found that the brain can literally grow new connections with stimulation from the environment, thus allowing for better brain cell communication and improved learning.

Diamond's research highlights the importance of the learner interacting with his or her environment to attain the goal of learning something new. The need for appropriate, effective environments in many shapes, sizes, and forms is inherent. William Greenough has studied the effects of enriching and stimulating environments on human brain development for more than 20 years (Jensen, 1998). His research identifies two particularly important attributes of enriched learning environment. First, the learning environment must be challenging to the learner, with new information or experiences. Second, there must be some way to learn from the experience through interactive feedback.

Greenough's first attribute demonstrates how relevancy, an aspect critical for successfully mediating learning, is important. At a biological level, relevant material and thoughts can activate entire neural networks.

The greater the number of links and associations that your brain creates, the more neural territories involved and the more firmly the information is woven in neurologically. . . . For many students, the problem is the opposite. Classroom information lacks the personal relevance for any meaning (Jensen, 1998, p. 92).

It is also worth noting how this "making of associations" parallels the research literature that addresses motivation and design of effective technology-based instruction. Establishing relevance to the instructional content is the second component of John Keller's (1998) ARCS model, a system for improving the motivational appeal of instructional materials. Malone and Lepper (1987) created a heuristic for designing intrinsically motivating learning environments that identifies features needed to enhance individual and interpersonal motivations. To enhance individual motivation, the heuristic calls for developing appropriate levels of challenge and feedback in the design of the instruction.

Technology can create learning environments that support the making of associations by providing access to new challenges, contexts, and information. Technology, through sound, text, and pictures, allows the user to experience people, places, and things that might otherwise be impossible in its absence. These multiple media, sometimes working alone and other times together, can create rich environments conducive to the acquisition of knowledge. One strategy is the use of stories to scaffold the acquisition of new knowledge.

The Role of Storytelling in Learning

Using stories to support learning has ancient roots. In countries where rich oral traditions still exist, folktales and stories have moral messages and have been a basic part of an informal education. We can find examples throughout history. The Greek playwright Euripides wrote one of the earliest "antiwar" plays, *The Trojan Women*, to address the evils of war, and early British and American fiction writers used the wisdom of biblical texts to promote moral education (Brown and Meeks, 1997, p. 31).

Today, film and television are primary means for storytelling from which, as in earlier eras, people learn informally. A good deal of evidence exists proving that these media can encourage adoption of values, beliefs, and behavior across a range of topics—adult literacy, sexual responsibility among teens, health education, and volunteerism (Rushton, 1982, as cited in Brown and Meeks, 1997). Over the past 30 years, a number of film and television producers have intentionally sought to educate the public about important issues using these media. Some examples include the 1970s television series *Roots*, about the history of African-Americans' journeys from slavery to freedom; *Schindler's List*, about the holocaust; *Mississippi Burning*, about the civil rights movement in the South; and *Cry Freedom*, about apartheid in South Africa.

Theories on Viewing and Learning from Entertainment Television

How do we learn from film and television? Over the years, two opposing theories have emerged in the literature regarding cognitive processing that occurs with entertainment viewing—a reactive theory and an active theory (Seels et al., 1996). The earlier, reactive theory suggested that the viewer was a passive entity who could react only to the stimuli being presented. Singer (1980) and Singer and Singer (1981), proponents of the reactive theory, suggested that the rapid pace and entertaining quality of television messages leave little or no time for viewers to process information at more than a superficial level and that frequent viewing over the long run might adversely influence learning and school achievement.

Virtually no reliable data confirm such a strong adverse effect, and "[r]esearch has generally supported an active hypothesis" (Seels et al., 1996, p. 316). The

Educational Theories Explaining How Learning May Occur via Entertainment

(Seels et al., 1996; Sprafkin, Gadow, and Abelman, 1992)

Arousal Theory:	Communication messages that can evoke varying degrees of generalized emotional arousal and that can influence any behavior in which an individual engages while in the state of arousal
Short-Term Gratification Theory:	Deals with affective and motivational components including enthusiasm, perseverance, and concentration
Interest Stimulation Theory:	Suggests that entertainment can spark a student's interest in, and imagination about, a topic and thus promote learning and creativity

active theory states that the attention that the learner gives to the program is not a reaction to stimuli (as in reactive theory), but rather, an ongoing and highly interconnected process of monitoring and comprehending. Hence, active television viewing by a child is not a simple response but a complex, cognitive activity that develops and matures with the child's development to promote learning.

Many other theories provide further understanding on how learning occurs with entertainment. Seels et al. (1996) name several—Arousal Theory, Short-Term Gratification Theory, Interest Stimulation Theory—all of which are based on the ability of the entertaining media to engage the learner, activate emotional states, initiate interest in a topic, and allow for absorption and processing of information.

Multimedia Defined

The preceding theories suggest that we can indeed learn from film and television. Stories can support the learning process by providing ideological scaffolding upon which new knowledge is organized. One reason these technologies prompt learning is the use of multiple media to present information. In the case of television and film, visual and auditory media combine to present a rich experience for the viewer.

Merriam-Webster defines "multimedia" as "using,

involving, or encompassing several media." Mayer (2001) conceptualizes multimedia across three areas: delivery hardware (i.e., computer screen, audio speaker, or television), presentation mode (i.e., words and/or pictures), and sensory modalities (i.e., auditory or visual).

Here, we define multimedia as a technology that employs media in different modalities perceived by the receiver. Examples abound: the sound and images at the heart of video or the text, images, and interactivity of computer-based instruction. Yet each of these examples can incorporate the audio and visual modalities in infinite ways. Audio can be used with the spoken word or to support emotion through music. Sound effects can punctuate a point. It has been said

that a picture is worth a thousand words, and multimedia can provide an almost limitless number of pictures and images.

Multimedia and Active Learning

For many, the typical classroom experience is a teacher imparting his or her wisdom through lecture and presentation. This one-way communication tradition has resulted in transmission of knowledge since the dawn of time. Yet, increasingly, it is being challenged. Educational technologies have the ability to go beyond audio. Not only can they present multiple media, but they can also prompt the learner to contemplate information, perform tasks, refine thinking, and demonstrate understanding. Multiple modalities (audio, visual) and active learning make this possible.

Researchers posit that explanations presented in words and pictures, as opposed to words or pictures, make for increased comprehension (Mayer, 2001) for the learner. Dale's "Cone of Experience" (1946, 1996) provides evidence of these phenomena. Dale's research suggested that increasing the modalities by which content was presented could increase retention rates. Wiman and Mierhenry (1969) extended Dale's concept to conclude that people will generally remember

- 10 percent of what they read
- 20 percent of what they hear

- 30 percent of what they see
- 50 percent of what they hear and see

Paivio (1986) provides an explanation of this need to address multiple modalities:

Human cognition is unique in that it has become specialized for dealing simultaneously with language and with nonverbal objects and events. Moreover, the language system is peculiar in that it deals directly with linguistic input and output (in the form of speech or writing) while at the same time serving a symbolic function with respect to nonverbal objects, events, and behaviors. Any representational theory must accommodate this dual functionality (p. 53).

Engaging the learner through text and visuals has proved an effective means to enhance retention. But placing the learner in the middle of the content and responsible for making decisions and acquiring knowledge takes learning one step further. Confucius' quotation, "I hear and I forget. I see and I remember. I do and I understand," makes the point plainly: learning by doing results in new knowledge and retained knowledge. Active learning involves putting students in situations where they must read, speak, listen, contemplate, think deeply, write, and respond. Bonwell and Eison (1991) have defined the following attributes of active learning:

- students are involved in more than listening;
- less emphasis is placed on transmitting information, and more emphasis is placed on developing students' skills;
- students are involved in higher-order thinking (e.g., analysis, synthesis, evaluation);
- students are engaged in activities (e.g., discussion, writing, kinesthetic activities); and
- greater emphasis is placed on students' explorations of their own attitudes.

By putting the learner in control of the learning environment, educational software can support each of these active learning attributes. Simulation programs such as *SimCity* put the user in the middle of the action, planning and managing a burgeoning city. Authentic results, the success or downfall of the city, promote powerful lessons and understanding. Searching, reviewing, synthesizing, and reporting

information accessed from the Internet is another example of active learning via technology. WebQuests are one example of how teachers are using the World Wide Web to promote active learning (see <http://webquest.sdsu.edu/webquest.html>).

Multiple Intelligences

Sources for creating enriched learning environments are infinite. We can draw from reading and language, sports and physical exercise, thinking and problem solving, and music and the arts, as well as our immediate surroundings. A child's brain is equipped with multiple neural pathways waiting to be developed. This means that it is critical to expose students to a variety of approaches to solving problems (Gardner, 1993).

According to Gardner's multiple intelligences theory, individuals possess numerous mental models, which differ from individual to individual in their relative strengths and preferences. Gardner proposes that there are at least eight discrete intelligences: linguistic, logical-mathematical, spatial, musical, bodily kinesthetic, interpersonal, intrapersonal, and naturalistic. The relative strengths and weaknesses among and between these intelligences dictate the ways in which individuals take in information, perceive the world, and learn.

Most traditional textbook approaches to teaching a particular subject favor a linguistic or narrative approach. Such an approach will fail to reach those who may respond better to an artistic or naturalistic depiction of the topic. In addition, it also fails to develop those other neural connections and pathways and further enhance those intelligences.

This is where technology-based approaches incorporating video and audio (in other words, multimedia) allow education and, in effect, learning to reach more students and provide more opportunities for neural development and learning. Shirly Veenema and Howard Gardner (1996) discuss at length how designers created the CD-ROM *Antietam/Sharpsburg* to appeal to and develop these different intelligences. For example, to tell the story of the Civil War, *Antietam/Sharpsburg* uses accounts from different eyewitnesses, provides close-up views of physical sites and artifacts, and provides photographic sequences that allow students to walk the battlefield.

Similarly, *The Mystery of the Mission Museum* (<http://mystery.sdsu.edu>) is a virtual-reality educational

CD that takes students to a virtual California Mission. The software allows students to actually visit interior rooms and exterior activity areas in the Mission, virtually manipulate dozens of objects and artifacts, conduct “interviews” with Mission Indians and Spaniards, and view demonstrations of 18th- and 19th-century crafts, as well as read and hear authentic Mission-era texts and music.

Another example is *The Oregon Trail II*, an educational multimedia CD game that recreates the journey many pioneers took in their trek westward. Students playing the game encounter unique situations presented using photo-realistic images and scenes. Along the way, students build real-life decision-making and problem-solving skills as they struggle to reach the West.

Summary

In this section, we’ve made the point that learning is the process of making connections.

- The brain is constantly working to make associations between existing knowledge and new information it receives.
- Educational technology can employ diverse approaches to support this process of learning.
- Storytelling is an ancient and proven strategy used to scaffold information and knowledge, facilitating the transfer from one person to another.
- Presenting information in multiple modalities (audio, visual, textual) can increase the chance that learning will occur.
- People generally remember 10 percent of what they read, 20 percent of what they hear, 30 percent of what they see, and 50 percent of what they hear and see.
- Active viewing of media by children is not a simple response but is a complex, cognitive activity that develops and matures with the child’s development to promote learning.
- The ability of media to engage the learner, activate emotional states, initiate interest in a topic, and allow for absorption and processing of information shares a direct relationship to the potential that learning will occur.

Gardner's Multiple Intelligences

Linguistic:	Gain meaning and are good at using words, either orally (storyteller, lawyer) or in print (journalists, poets, and voracious readers)
Logical-Mathematical:	Typically scientists, accountants, and computer programmers; have strong ability to use numbers and reason well
Spatial:	Involves thinking in pictures and images; often architects, engineers, or artists; can clearly visualize in three dimensions and sketch ideas
Musical:	Exemplified in musicians and in those who can readily perceive and express music — i.e., those with a good ear who can sing in tune
Bodily Kinesthetic:	Applies to those hands-on people who have good tactile sensitivity (mechanics, craftspeople, or surgeons) or to those who use their bodies to express ideas and feelings (athletes, dancers, actors)
Interpersonal:	Capable of perceiving and responding to moods and desires of others; understand and work well in groups
Intrapersonal:	Applies to those who are very introspective and can easily access their own feelings; often prefer to work on their own
Naturalistic:	Can easily recognize and classify plants, animals, and other things in nature

Research-Based Evidence: Learning with Educational Technology

Education is what survives when what has been learned has been forgotten.

B. F. Skinner, 1964

Research evaluating technology and learning has a long history. The beginnings date back to the Payne Fund studies of the 1930s, one of the first large-scale efforts to investigate media's role in influencing people (Krendl, Ware, Reid, and Warren, 1996). Study findings supported the potential of the film as an informal learning instrument. These studies linked a film's ability to educate with a combination of important qualities inherent in the medium: wide variation in content, gripping narrative techniques, and an appeal to basic human motives and wishes.

The expansion of television programming and viewing in the mid-20th century set the stage for investigating how television entertainment impacted children. Schramm, Lyle, and Parker conducted the first major exploration of this premise in 1961 (as cited in Krendl et al., 1996). The study emphasized how children learn from television viewing and developed the concept of "incidental learning." Although the viewer's intent is entertainment, he or she stores up certain information without seeking it and learning occurs in spite of the intention of the program or of the viewer.

Seels and his colleagues conducted an exhaustive review of the research on learning from television:

After 40 years, the collective evidence that film and television can facilitate learning is overwhelming. This evidence is available for all forms of delivery, film, ITV [instructional television], ETV [educational television], and mass media (Seels, et al., 1996, p. 345).

This section highlights, in depth, *Sesame Street*—one of the most researched efforts of educational television—and discusses additional examples such as *Schoolhouse Rock*, Court TV's *Choices and Consequences*, *Blue's Clues*, *Mr. Rogers' Neighborhood*, and *The Electric Company*. Research surrounding the educational use of computers in the classroom, including the Internet, is also presented.

Evidence of Learning: Television and Video

Sesame Street. Without a doubt, *Sesame Street* is one of the best-known examples of merging education and entertainment. From its conception in 1968, the pro-

gram sought to be a very different kind of children's television series. It was different in its high production values, its topics, and its instructional goals. It was revolutionary in its use of animated characters to breathe life into its educational curriculum.

Sesame Street's commitment to research was also revolutionary. The earliest research was done in-house or commissioned by the CTW (Children's Television Workshop), now called the Sesame Workshop. Later researchers added to this pool so that "[c]ollectively, there is now more research on the effects of *Sesame Street* than for any other television program or series in the entire history of the medium" (Mielke, 2001, p. 83). *Sesame Street* was among the first to conduct research during production to help make decisions on how to better meet the educational goals of the program. Palmer and Fisch (2001) describe one instance of how such formative research was used:

Data on this segment, and others like it, convinced both producers and researchers of the importance of considering not only the attractiveness of the material and not only what children could comprehend, but also the interaction between attraction and comprehension. When humor, dramatic tension, or other attractive features were made to coincide with the heart of the educational message, this interaction could be used to enhance the effectiveness of the educational content. Yet, when the two did coincide, children would recall the attractive material and not the educational message (p. 12).

In their summary chapter of the book "*G* is for growing: *Thirty years of research on children and Sesame Street*, Fisch and Truglio (2001) point to "a consistent pattern of significant effects" (p. 233) in academic areas, emergent literacy, school readiness, and social behaviors. This was seen in the very first studies conducted in the early 1970s by Ball and Bogatz (1970; Bogatz and Ball, 1971) who demonstrated that the children who watched the most, learned the most. This was true regardless of age, viewing, geographic location, socioeconomic status, or gender. Numerous subsequent studies have further demonstrated the positive impact of *Sesame Street* viewing on children's learning and school readiness (see box on page 17).

Today, *Sesame Street* remains as popular and as relevant as ever. February 2002 brought the 33rd anniversary of *Sesame Street's* first viewing. During that month, one of four new episodes written in response to the September 11 tragedy was aired, with Elmo learning about fires, firefighters, and post-trauma jitters.

Research Highlights: 30 Years of Sesame Street

Bogatz and Ball (1970)

- Of the children who watched *Sesame Street*, those ages 3 to 5 learned the most; as their viewing increased, so did their gain scores on various early childhood assessments.
- Topics that received greater screen time (i.e., letters) were more likely to be learned when compared with topics that received less screen time.
- Children who viewed the program at home gained as much as children who viewed the program in school under the supervision of a teacher.

Bogatz and Ball (1971)

- Teachers rated frequent viewers higher in the areas of general readiness for school, quantitative readiness, positive attitudes toward school, and relationships with peers.

Paulson (1974)

- Conducted earliest study on *Sesame Street* and its impact on prosocial learning, focusing on cooperation.
- Found that *Sesame Street* viewers cooperated more than those who did not view the program.

Reiser, Williamson, and Suzuki (1984)

- Showed that cognitive learning increased when adults who watched *Sesame Street* with children asked them questions about letters and numbers and gave feedback.

Rice, Huston, Truglio, and Wright (1990)

- Conducted two-year longitudinal study of 326 children and their families, which studied vocabulary acquisition among children 3 to 7 years old; they found that for children ages 3 to 3.5, *Sesame Street* viewing was a significant predictor of vocabulary scores achieved when reaching age 5.
- Children's viewing of programs without specific educational intent, such as most cartoons, was not associated with increased vocabulary.
- Most viewing was without parents, suggesting that children could learn vocabulary even when not accompanied by parents.
- Associations of increased vocabulary held regardless of parent education, family size, child gender, or parental attitudes toward television.

Rice (1990); Rice and Sell (1990)

- Explored the use of four *Sesame Street* videocassettes in the natural home setting with 20 children, ages 2 to 5, and their families.
- Documented gains in vocabulary, letter recognition, number recognition, and word identification.
- Interpreted the learning effects as “remarkable,” considering that children averaged only 2.5 to 3 hours of viewing each tape over 11 weeks.

Wright, Huston, and Kotler (2001)

- Three-year longitudinal study found that viewing *Sesame Street* was positively associated with subsequent performance in reading, mathematics, vocabulary, and school readiness.
- Findings held true even when the effects of socioeconomic status, mothers' education, and educational quality of home environment were statistically controlled.

Zill (2001)

- Results from national survey found significant correlations between *Sesame Street* viewing and preschoolers' ability to recognize letters and tell connected stories when pretending to read.
- Upon entering 1st and 2nd grade, children who viewed *Sesame Street* as preschoolers were more likely to read storybooks on their own and less likely to require remedial reading instruction.

Huston, Anderson, Wright, Linebarger, and Schmitt (2001)

- Researchers conducted a “recontact” study — a sample of high school students whose preschool television viewing had been tracked 10 to 15 years ago in earlier studies.
- Adolescents who viewed *Sesame Street* often at age 5 had significantly better grades in English, science, and mathematics; read more books for pleasure; and had higher motivation to achieve.

Blue's Clues. Premiering on television in September 1996, *Blue's Clues* changed the way preschool children watched television. The lead characters, Steve and Blue, encouraged their young viewers to work with them to actively solve problems. Children were no longer just passive audience members but an integral part of the show.

A team of researchers at the University of Alabama (Bryant et al., 1998) sought to determine if this innovative approach worked to achieve its learning objectives. To do this, they conducted a longitudinal investigation, collecting data at four different times during the first season from 120 preschoolers who lived in five states. Of these 120, 64 were regular viewers and 56 were unable to receive Nickelodeon and could not watch *Blue's Clues*. Data were collected across a number of different measures for both groups. Data analysis results clearly showed strong effects on developing preschool viewers' flexible thinking, problem solving, and prosocial behaviors when compared with children who did not watch the program.

Choices and Consequences. Recent increases in school violence have called attention to the fact that adolescents are at greater risk of being involved in violence than any other age group (American Psychological Association, 1993). The *Choices and Consequences* program, created by Court TV in association with Cable in the Classroom, seeks to address the harmful effects of violence by "resensitizing" adolescents to the risks associated with aggressive and antisocial behaviors. The program includes three case-based study units that revolve around actual trials involving teenage perpetrators and victims. Each unit features a trial-story videotape and guided discussion around empathy, risk assessment, decision making, and role-play.

The *Choices and Consequences* Evaluation, conducted by the Center for Communication and Social Policy at the University of California, Santa Barbara, evaluated the impact of the *Choices and Consequences* program on middle school students (Wilson et al., 1999). Five hundred and thirteen seventh- and eighth-grade students participated in the study over a three-week period. Eleven classrooms completed the *Choices and*

Consequences curriculum (the curriculum group), and 10 classrooms did not (the control group). A predesign and postdesign assessed students' legal knowledge, empathy, perceptions of risk, and antisocial behavior. The study documented the following results:

- *Choices and Consequences* impacted students' acquisition of legal terms and the American court system; participating students demonstrated understanding of an additional eight legal terms on average, compared with no change in the control group.
- Although both groups demonstrated similar scores regarding "empathy toward other people" as measured by the pretest, students participating in the program scored appreciably higher on the posttest, while control group empathy scores remained essentially unchanged.
- *Choices and Consequences* reduced adolescents' verbal aggression, including tendencies to tease, swear at, and argue with others, compared with a slight increase in the control group.
- The *Choices and Consequences* curriculum held constant the curriculum group's self-reports of physical violence, while self-reports of physical violence increased in the control group.

Some Studies Pointing to the Ability of Music to Enhance Memory

When letters of the alphabet were connected to musical pitch, recognition was enhanced among slow-learning children (Nicholson, 1972).

Several experiments have concluded that learning is enhanced when new information is presented in song (Chazin and Neuschatz, 1990; Gingold, 1985).

In a study, Wakshlag, Reitz, and Zillmann (1982) found that children liked music with a fast, marked tempo; clear, distinct rhythms; and repetitive melodies, leading the researchers to suggest that such music may invite learning and be more easily learned.

Schoolhouse Rock. Originally aired from 1973 to 1985, *Schoolhouse Rock* combined animation and catchy musical lyrics in a series of three-minute educational television cartoons to teach viewers lessons in history, grammar, multiplication, science, government, and finance. *Schoolhouse Rock* was the result of advertising executive David McCall's desire to help his 11-year-old learn his multiplication tables. To McCall, the solution seemed obvious: Why not use pop music to help kids learn? Hence, *Schoolhouse Rock* was born.

Unlike *Sesame Street*, little academic research exists regarding the impact of *Schoolhouse Rock* on learning among children. One of the few studies to assess its value looked at the ability of 4- to 11-year-olds to distinguish among television programming genres and comprehend the information presented. In that study, Blosser and Roberts (1985) found that *Schoolhouse Rock* ranked as one of the two best-understood messages. Most of the evidence of its efficacy is anecdotal. Even though it has been 20 years since its first telecast, Engstrom (1995) notes how the mere mention of *Schoolhouse Rock* often leads original viewers to sing various songs and describe images from Rock segments.

It is notable that although the program was based on a hunch that music enhances learning, several studies provide evidence demonstrating the effectiveness of music as an attention getter and mnemonic device (see table). *Schoolhouse Rock* songs such as "Conjunction Junction," "What's Your Function," and "We the People" extensively use repetitive melodies and lyrics repeated in short and easy-to-remember phrases.

Today, ask a young adult to recall the words in the U.S. Constitution and you may be treated to those words accompanied by a melody. The music adds form to the words, creating a pseudo-mnemonic device that scaffolds the content and prompts its place in long-term memory.

Mister Rogers' Neighborhood. After 33 years, *Mister Rogers' Neighborhood* was PBS' longest running series when it stopped producing new episodes in 2001. The program targeted 2- to 6-year-old children and focused on developing learning readiness, which encompassed creating a sense of self-worth, a sense of trust, curiosity, a capacity to look and listen carefully, a capacity to play, and times of solitude. Research conducted by Coates, Pusser, and Goodman (1976) shows that the program was generally successful in achieving these goals.

The Electric Company. Aired on PBS for five seasons during the 1970s, *The Electric Company* used musical and comedy sketches, cartoons, and demonstrations to teach its audience. The program was initiated as an experiment in using video to teach decoding skills for print medium and targeted children in early elementary grades who needed remediation in reading. The program focused on blending consonants, chunking letter groups, and scanning for patterns. Research conducted by Stroman (1991) showed that African-American children improved learning after viewing these programs. Graves' work (1982) demonstrated that learning increased and reading improved when children viewed these programs with an adult, pointing to the important role that adults and teachers play in learning.

Evidence of Learning: Computers

Apple Classrooms of Tomorrow. Initiated in 1985 and concluded in 1998, Apple Classrooms of Tomorrow (ACOT) was a collaborative effort among public schools, universities, research agencies, and Apple Computer, Inc. The project sought to find out what happens when students and teachers have immediate and constant access to a wide range of technology—computers, videodisc players, video cameras, scanners, CD-ROM drives, modems, and online communications services, along with a variety of software, including word processors, databases, spreadsheets, and graphics packages. During its 13 years of research, ACOT studied learning, assessment, teaching, teacher development, school design, the social aspects of education, and the use of new technologies in more than 100 elementary and secondary classrooms nationally.

After studying more than 30 ACOT teachers and 650 students at five sites from 1986 to 1989, ACOT researchers (Dwyer, Ringstaff, and Sandholtz, 1990; Ringstaff, Sandholtz, and Dwyer, 1991) demonstrated that providing immediate access to technology in the classroom substantially changes the way teachers instruct and students learn. As they collected and studied both quantitative and qualitative data, they saw new patterns of learning and teaching emerge more or less in stages. As teachers moved through these stages, traditional teaching methods were initially strengthened by technology and then gradually replaced by more engaging and student-oriented activities. Teachers noted students exhibiting highly evolved technology skills, becoming more actively involved on

their own, and moving away from competitive to collaborative work patterns. In the later stages, teachers increasingly relied upon students as experts, with students presenting to the class, demonstrating technologies to small groups, and working as peer tutors.

ACOT research also shows that when technology is used to support collaborative and constructivist learning, it can significantly increase students' potential for learning. ". . . [I]ndependent researchers found that students in ACOT classrooms not only continued to perform well on standardized tests but were also developing a variety of competencies not usually measured" (Apple Computer, Inc., 1995, p. 10).

- Sandholtz, Ringstaff, and Dwyer (1997) conducted a longitudinal study of ACOT project students and found that ACOT students typically used inquiry, collaborative, technological, and problem-solving skills that were atypical in graduates of traditional high school programs.
- In another longitudinal study, Penuel, Golan, Means, and Korbak (2000) studied the effects on students of ACOT's focus on problem-based learning. To do this, researchers asked groups of ACOT and non-ACOT students to create a brochure. The brochure was rated across a variety of standards, including understanding of content as well as attention to external audience and overall design. They found that ACOT students outperformed non-ACOT students.

- Gearhart, Herman, Baker, Novak, and Whittaker (1994) found that students who were the most successful at peer tutoring in ACOT classrooms did not typically have the highest grades. The researchers suggested that teachers may not know how to translate students' teaching skills into a grade and that alternative forms of assessment may be needed.
- Coley (1997) found that ACOT students demonstrated improved school attendance, decreased dropout rates, and increased feelings of independence and responsibility for their own learning.

Apple K–12 Effectiveness Studies. To provide easy access to current research findings about the general effectiveness of technology in education, Apple has compiled research on the effectiveness of technology in K–12 learning into a series of Apple K–12 Effectiveness Reports. Collectively, this research demonstrates and documents the impact of technology across content areas and grade levels.

Multiple studies point to the benefit of using technology to enhance student learning in elementary school language arts, science, and mathematics; middle school language arts, science, mathematics, and social studies; and high school mathematics, science, and writing. In addition to developing students' basic skills, technology use also positively affects students' preparation for success in the workplace (Imel, 1992).

Highlights of Apple K-12 Effectiveness Reports

(Based on <http://www.apple.com/education/k12/leadership/effect.html>)

Elementary School Language Arts

- Children quickly learn to use word processing software, often doing better writing than they do with pencil and paper (Johnston and Olson, 1989).
- Using word processing results in fewer grammar, punctuation, and capitalization errors, especially among students with low abilities (Cheever, 1987).
- Authentic writing with computers is an effective way of learning language mechanics, with improvements showing up on holistic assessments and standardized tests (Riel, 1989, 1990).
- When children use a computer to study spelling, they are more engaged and achieve higher spelling scores. (MacArthur, Haynes, Malouf, Harris, and Owings, 1990)

Elementary Science and Mathematics

- Computers help students of all abilities learn science content while increasing logical thinking and problem-solving skills (Kirkwood and Gimblett, 1992; Ziegler and Terry, 1992).
- Students show greater achievement on standardized tests after using computers for mathematics problem solving (Clouse, 1991-92[b]; Phillips and Soule, 1992).
- Students working collaboratively to explore science concepts are effective and successful when they use a local-area network (Newman et al., 1989).
- Children using computers in mathematics are more independent learners and prefer learning on computers to learning with worksheets or precision teaching (Vacc, 1991-92).

Middle School Language Arts

- When word processing use is combined with effective teaching models, students achieve at a higher level than those not using a word processor (Snyder, 1993).
- Remedial reading students using computer reading games for reinforcement and remediation showed significant gains and improved attitudes toward reading (Arroyo, 1992; Nixon, 1992).
- Students using laptop computers to keep journals, write stories, and complete assignments showed marked improvement in their ability to communicate persuasively, organize ideas logically, and use a broad vocabulary effectively (McMillan and Honey, 1993).
- Students using computers improve the quality of their writing and learn knowledge-transforming and text-construction strategies. More experienced writers improve their existing competencies in creating narrative (Elliot, 1992).
- Students in an inquiry-based curriculum using a variety of computer technologies acquired significant amounts of content knowledge and developed a positive self-image (Persky, 1992).

Middle School Social Studies

- The computer can be a powerful tool for the delivery of critical-thinking and problem-solving activities in the social studies classroom (Repman, 1993).
- Students can use computers to graph, help interpret information, and apply that knowledge in social studies (Jackson, Berger, and Edwards, 1992).
- Students using computers in a history class demonstrated increased motivation and recall and took less time to complete the unit (Yang, 1991-92).

Highlights of Apple K-12 Effectiveness Reports

(Based on <http://www.apple.com/education/k12/leadership/effect.html>)

Middle School Science and Mathematics

- Using computers for performing graphing functions seems to aid students' understanding of science concepts and removes the drudgery of creating the physical graph (Linn and Songer, 1991; Mokros and Tinker, 1987).
- Students who used computers to create computational models of scientific processes dealt with more complex problems than those without modeling software (Miller, 1993).
- Computer tools in science help students understand and master high-level science concepts, working through a progression of conceptual levels (Eylon and Linn, 1991; Linn, Songer, Lewis, and Stern, in press).
- Students spend more time analyzing and interpreting data when they use computers in an integrated, problem-based curriculum (Mevarech and Kramarski, 1992).

High School Writing

- When students use word processing to write, there is a significant improvement in their attitudes toward self, teachers, and writing (Kurth, 1987).
- Low-achieving writers benefit from participation in telecommunications-based writing projects in which they are intrinsically motivated in a real communications environment (Spaulding and Lake, 1991-92).
- Urban LEP students improve their writing by using word processing and become more positive about school and about writing (Silver and Repa, 1993).
- Significant performance differences are realized between students using computers and those writing essays by hand. Students who used computers received higher performance scores and higher grades on their essays (Robinson-Steveley and Cooper, 1990).

High School Science

- Students learn more efficiently when they can watch the science event and its real-time graphic representation simultaneously. Simply using computers for graphing seems to aid students' understanding of science concepts and removes the drudgery of creating the physical graph (Brasell, 1987; Linn, Layman, and Nachmias, 1987).
- Computerized simulation expands classroom inquiry and improves learning. Working with simulations encourages students to think hypothetically and to use complex strategies with variables (Mintz, 1993; Rivers and Vockell, 1987).
- Learning-disabled (LD) students using computer simulations scored significantly higher than did traditionally taught students—both LD and non-LD—on recall of basic information and problem-solving skills (Woodward et al., 1988).
- Computer modeling and visualization in physics allow advanced science students to spend more time in active scientific inquiry (Shore et al., 1992).

High School Mathematics

- Students who use computers in mathematics have more positive attitudes about their mathematics abilities and about mathematics in general, and show significant gains in problem-solving ability and content knowledge (Funkhouser, 1993).
- Students who work in small groups on geometry problems using geometry software showed improvement on higher-level problem solving and applying mathematics applications and received significantly higher scores on standardized final exams (McCoy, 1991).
- Students using computers for algebra did significantly better on a knowledge test than a traditionally taught group; the computer group retained more information and scored significantly higher on measures of transfer to other areas of mathematics (Al Ghamdi, 1987).

Kulik's Meta-Analysis Study of Computer-Based Instruction. James Kulik (1994) took findings from more than 500 individual research studies of computer-based-instruction (CBI) and conducted a meta-analysis. In CBI, instruction is customized to meet individual students' needs, interests, current knowledge, and learning styles. The results of his analysis showed that students using CBI typically

- scored at the 64th percentile compared with students without computers who scored at the 50th percentile on achievement tests,
- learned more in less time, and
- liked their classes more and developed positive attitudes.

NAEP Study of the Impact of Technology on Mathematics Achievement. Harold Wenglinisky (1998) conducted a national assessment on the impact of technology on mathematics achievement using results from the National Assessment of Educational Progress (NAEP) of more than 6,000 fourth-grade and 7,000 eighth-grade students. His analysis controlled for differences in socioeconomic status, class size, and teacher characteristics so that the reported outcomes represented the value added by technology. Results revealed a positive impact on student mathematics learning and included the following:

- Eighth-grade students showed gains in mathematics scores of up to 15 weeks above grade level.
- For both fourth- and eighth-grade students, teacher professional development and higher-order computer use were positively associated with academic achievement.

West Virginia Basic Skills/Computer Education (BS/CE). The BS/CE technology implementation spanned the entire state for a full decade. The scale, consistency, and focus of this program provide a firm foundation for evaluating the program.

The BS/CE program consisted of three major components:

- software focusing on the state's basic skills goals in reading, language arts, and mathematics;
- enough computers in schools to provide all students with easy and regular access to basic skills software; and

- teacher professional development in the use of computers in general and of the BS/CE software specifically.

Authorized in 1989–90, the program began with the kindergarten class of 1990–91. Data collected in an extensive study by Mann et al. (1999) reveal a very positive program impact in terms of student outcomes. As the 1990–91 kindergarten class progressed from one grade to the next, test scores increased. For example, when the first “technology-enhanced” cohort arrived in third grade, statewide CTBS (California Test of Basic Skills) scores went up 5 points, having risen only about 1.5 points per year for the previous four years. When this group reached fifth grade, analyses showed gains in the Stanford-9 achievement test, with higher gains for the students with more BS/CE experience. Mann and his colleagues also conducted a regression analysis and concluded that BS/CE technology accounted for at least 11 percent of the total variance in the basic skills achievement gain scores of the fifth-grade students.

The impact of the BS/CE program on students of lower socioeconomic status is worthy of note: Although the program helped all children perform better, the study data show that BS/CE helped the neediest children to the greatest extent. Children without computers at home made the biggest gains in total basic skills, total language, language expression, total reading, reading comprehension, and vocabulary.

Sivin-Kachala and Bialo Review of Technology Effectiveness Studies. Jay Sivin-Kachala and Ellen Bialo regularly conduct one of the largest reviews of research studies on the effectiveness of technology on student achievement. In the 2000 study, commissioned by the Software and Information Industry Association, Sivin-Kachala and Bialo (2000) reviewed 311 such studies. The evaluated studies crossed most subject areas and included students of all ages. Results revealed positive and consistent patterns when students were engaged in technology-rich environments. Overall, their review demonstrated the following:

- significant gains and achievement in all subject areas,
- increased achievement in preschool through high school for both regular and special needs students, and
- improved attitudes toward their own learning and increased self-esteem.

Teachers Keep the Gate

This section has illustrated how technology supports learning and provided researched-based results achieved with educational technologies. Yet, in most cases, these results would not have been attained without the thoughtful, purposeful use directed by their teachers. Effective classroom use involves planning and purposeful application of technology and the content it delivers to learning objectives and instructional pursuits. In the classroom, this responsibility falls largely on the teacher. The teacher is gatekeeper—to instruction, technology, and learning. We've suggested that teachers will make use of educational technologies when they hold the belief that use of such technologies results in learning. When this is not the case, technology receives casual use at best, or simply remains unused. The dust-covered computers and software on many classroom shelves provide convincing evidence.

Teaching with Technology

The fact that teachers play an important role if students are to learn effectively using video and television is supported by research. Graves (1987) found that the potential of television's impact is increased when teachers are involved in its selection and use and when teachers are trained in the use of television for instruction. Johnson (1987) reported that, although television can teach in a stand-alone environment, it teaches best when teachers are involved.

Such reports further emphasize that teacher perspectives and attitudes on the use of educational television and video are particularly germane to any technology-based learning endeavor. In Spring 1997, the Corporation for Public Broadcasting (Corporation for Public Broadcasting (CPB), 1997) commissioned a study to assess and evaluate the use of television and video in our nation's schools. The resulting survey data from 1,059 principals and 1,285 teachers and interview data from 127 teachers yield a rich and accurate accounting of how teachers perceive the impact television and video have on their teaching and on student learning.

Teachers are overwhelmingly positive about the impact television and video have on their teaching. Ninety-two percent say that television and video help them teach more effectively, and 88 percent find that these technologies allow them to be more creative in their teaching. In a typical week, teachers use television or video for 88 minutes, varying from 82 minutes in elementary schools to 94 minutes in senior high schools.

Teachers are also positive about the impact of the experience on their students. Seventy-five percent of teachers reported that the most pronounced impact of television and video use was that students understand and discuss the content and ideas. Teachers credit television and video not only for increasing students' motivation and enthusiasm for learning (63%) but also for improving their learning (56%). It is worthy of note that frequent users are even more likely to realize these benefits. Although the benefits of television and video are evident for all types of students, they are especially so for learning disabled and economically disadvantaged students. More than 50 percent of teachers rated television and video as "very effective" for these types of students.

The vast majority of teachers (86%) (CPB, 1997) have access to both television and computers. Yet, even with both media present, most teachers report that computers have not changed their classroom use of television and video; almost 25 percent said that their use of television and video has actually increased (CPB, 1997). Comments from two teachers participating in the CPB study further illuminate this phenomenon:

Computers have stimulated my use of television and video because they have made me more aware of technology.
Elementary School Teacher

The advent of computers has forced me to use television and video more constructively.
High School Teacher

From Purveyor of Knowledge to Learning Coach

Research also shows that when technology enters the classroom, teachers become facilitators and coaches of learning and students more frequently engage in collaborative learning. Apple Classrooms of Tomorrow (ACOT) research demonstrated that providing immediate access to technology in the classroom substantially changes the way teachers instruct and students learn (Dwyer et al., 1990; Ringstaff et al., 1991). Engaging, student-oriented activities gradually replace the traditional, teacher-centered teaching methods. In these classrooms, students exhibit highly evolved technology skills as they become more actively involved in their own learning and move from competitive to collaborative work with their peers.

ACOT research also shows that when technology is used to support such collaborative and constructivist learning, it can significantly increase students' potential

for learning. “. . . [I]ndependent researchers found that students in ACOT classrooms not only continued to perform well on standardized tests but were also developing a variety of competencies not usually measured” (Apple Computer, Inc., 1995, p. 10). Yet ACOT researchers also “. . . discovered that teachers are the key to creating such learning environments” (Apple Computer, Inc., 1995, p. 14).

Findings of the ACOT studies, including the potential of technology to affect teaching practice, continue to resonate. Recent viewpoints expressed by the U.S. Department of Education’s Web-based Education Commission illustrate the contemporary need to transform teaching and the promising outcomes that can result — for student and teacher alike. This is the vision that many schools, universities, and individual teachers are striving to accomplish across the nation today:

It is the teacher, after all, who guides instruction and shapes the instructional context in which the Internet and other technologies are used. It is a teacher’s skill at this, more than any other factor, that determines the degree to which students learn from their Internet experiences. Teachers must be comfortable with technology, able to apply it appropriately, and conversant with new technological tools, resources, and approaches. If all the pieces are put into place, teachers should find that they are empowered to advance their own professional skills through these tools as well. (*U.S. Department of Education, 2000, p. 39.*)

This vision holds technology as one of many tools employed by teachers to meet student needs and support learning. The success of such tools requires purposeful use, matched to each student’s unique needs. Just as a doctor prescribes medicine based upon symptoms and diagnosis, so too must the teacher understand the individual needs of his or her students and then provide matched opportunities for learning - including technology-delivered content. It is ridiculous to consider one particular medicine as a cure for all illnesses. Likewise, technology is not the solution for all that ails. Rather, we must increasingly rely upon the teacher’s expertise to craft blended opportunities for students to learn. These opportunities include video- and computer-based learning standing alongside complementary interventions, including direct instruction, collaborative group projects, textbooks, learning centers, manipulatives, and one-on-one tutoring.

Summary

This section has presented diverse results of research proving that students can and do learn from educational technology. The following research results are among the significant findings that support this conclusion:

- Watching the television program *Blue’s Clues* has strong effects on developing preschool viewers’ flexible thinking, problem solving, and prosocial behaviors when they are compared with children who do not watch the program (Bryant et al., 1998).
- Court TV’s *Choices and Consequences* program reduced middle school students’ verbal aggression, including tendencies to tease, swear at, and argue with others (Wilson et al., 1999).
- Viewing *Sesame Street* was positively associated with subsequent performance in reading, mathematics, vocabulary, and school readiness (Wright, Huston, and Kotler, 2001).
- A “recontact” study with a sample of 15- to 20-year-olds found that those who had been frequent viewers of *Sesame Street* at age 5 had significantly better grades in English, science, and mathematics; read more books for pleasure; and had higher motivation to achievement (Huston et al., 2001).
- Students show greater achievement on standardized tests after using computers for mathematics problem solving (Clouse, 1991–92; Phillips and Soule, 1992).
- Remedial reading students using computer reading games for reinforcement and remediation showed significant knowledge gains and improved attitudes toward reading (Arroyo, 1992; Nixon, 1992).
- Learning-disabled (LD) students using computer simulations score significantly higher than traditionally taught students (both LD and non-LD) on recall of basic information and problem-solving skills (Woodward, Carnine, and Gersten, 1988).
- Use of educational technologies accounts for at least 11 percent of the total variance in the basic skills achievement gain scores of fifth-grade students, as measured in a 10-year West Virginia statewide study (Mann et al., 1999).

View from the Future: Emerging Technologies

You can teach a student a lesson for a day; but if you can teach him to learn by creating curiosity, he will continue the learning process as long as he lives.

Clay P. Bedford

Today's classrooms continue to grow technology-rich. Almost all schools have computers that are used for instruction. School technology data for the year 2000 (Meyer, 2001) show that, on average, there are 4.9 students per instructional computer and 7.9 students per instructional multimedia computer. These data also show that a great majority of schools have access to the Internet, with 94 percent having at least one connection and 82 percent more than one (Meyer, 2001).

What Is Broadband Technology?

Envision a broadband Internet connection as a fat "pipeline" to Internet connectivity. Likened the difference between broadband and dial-up service to the difference between a fire hose and a garden hose. Then it is easy to imagine broadband technology carrying substantially larger amounts of voice, video, and data over the Internet in a quick and efficient manner.

Cable or telephone service providers typically furnish broadband connections. Cable, DSL, T1, T3, or a variation of these lines carries the broadband signal to a receiving device.

The introduction of broadband technologies to schools brings Internet services delivered at lightning-fast speeds and opens up a new class of Internet applications. These applications include videoconferencing, e-mail with audio and video components, sophisticated online games, and distance-learning applications.

Schools' broadband access to the Internet has vastly expanded, largely as a result of the "E-Rate" discount, created as part of the Telecommunications Act of 1996. By the year 2000, schools tended to use faster dedicated-line and broadband Internet connections. Seventy-seven percent of the nation's public schools

that were connected to the Internet used dedicated lines, and 24 percent used continuous types of broadband connection (National Center for Educational Statistics, 2001, May). This compares with 1996, when nearly 75 percent of public schools used dial-up Internet connections.

The number of connections in schools is also increasing. Previously, a "connected" school may have had a single Internet access point, often in the school office. Today, more than 82 percent of schools nationwide have Internet access in one or more classrooms. In fact, the amount of connectivity in these particular schools is even more encouraging: on average, 80 percent of the classrooms are connected to the Internet (Education Week, 2001).

Yet, access goes beyond connectivity. Findings of the Web-based Education Commission, formed by the U.S. Department of Education, suggest that:

Access must be convenient and affordable. It must offer a user the opportunity to find and download complex, content-rich resources. The technology that supports access must be where the learner is located and be available whenever he or she needs it. . . . Access also implies that once a user has the connection and is able to use it, he or she can find content and applications that have meaning and value for his or her learning needs. (U.S. Department of Education, 2000, p. 21)

In the future, classrooms and schools will continue to expand in the types and amounts of technologies available, and teachers will be challenged even more to appropriately integrate technologies into their curricula. Increased broadband Internet access and enhanced computers in schools will increase the use of technologies that merge video and desktop computing, such as webcasts, videoconferencing, digital movie making, and digital TV. Handheld computing and wireless technologies have also made entry into the classroom. Already, a small number of schools and classrooms are beginning to tap into these newer technologies. Below, we briefly highlight and review some of these new technologies and envision their contribution to learning.

Webcasts

Streaming video and audio transmitted from a server

and viewed on the desktop are often referred to as webcasts. Internet or broadband technologies (e.g., a software plug-in, such as RealPlayer or QuickTime) allow the user to view the video from his or her desktop. Live and archived webcasts provide K–12 students with opportunities to go beyond the classroom walls. One example is Apple's *Learning Interchange to QuickTime TV for Learning* <http://www.apple.com/education/LTReview/fall97/main2/default.html>, in which students can view an underwater video of a shipwreck, a live webcast from Houston Space Center, or a learning video on *Tyrannosaurus rex*.

Videoconferencing

Videoconferencing available on the desktop can provide teachers and students with opportunities to interact with others separated by a physical distance using real-time video and audio. As more schools gain broadband connections to the Internet, desktop videoconferencing using Internet-based connections is becoming increasingly available. The Global Schoolhouse was an early pioneer in this effort using *CU-SeeMe* to connect students and schools from various countries and cultures. Schools today are using tools such as *CU-SeeMe* and *NetMeeting* to support student learning and collaboration. Multiple videoconferencing applications are now available and provide students with opportunities as wide-ranging as interviewing NASA scientists or accessing tutoring services from home.

Digital Movie Making

Although camcorders and video presentations have long found their way into school projects, digital camcorders and desktop-computer video editing have made student control a much easier process. The use of digital video is a powerful way to motivate students, and, more important, students demonstrate higher-level thinking skills when producing digital video clips. A video may be the ideal format for the culminating product of a project-based learning experience. Formats can include video newscasts, documentaries, infomercials, or video clips for a Web page or multimedia presentation. One such example is a social studies teacher in Los Angeles whose students use digital video to report on their research on immigrants (Hoffenberg and Handler, 2001). Many of these students are immigrants or children of immigrants. For

the project, students videotape their interviews with family members and others and then edit videos to report on their projects.

Digital TV

Digital TV uses a revolutionary technology that is very different from the current analog system and presents great promise to further enrich the classroom (<http://www.cpb.org/digital/tv/whatis/>). Built more like a typical computer than a traditional television, a digital set looks a lot more like the wide-screen movies seen in theaters. Using digital technology, broadcasters can send extra “enhanced” material with televised programs, which allows viewers to interact with programs at their own pace. Students and other viewers can decide if and when they want more information on a particular program topic and, using a remote control, can call that data on to their television screens. At a viewer's prompting, additional data (i.e., text facts, graphics, video, audio) can be viewed. This enhanced material can be recorded for later use long after the program itself has been broadcast.

Handheld Technologies

Laptop computers provided the first opportunities to extend computer-based school curriculum from the classroom to the home. Despite the cost, a number of districts and schools made efforts to place a laptop with each student in the 1990s. With the advent of the personal digital assistant (PDA) and handheld technologies, districts are finding more affordable ways to do this. At Lessenger Middle School in Detroit, Michigan (<http://www.palm.com/education/studies/study9.html>), students use handhelds to make concept maps to learn about construction concepts. Then they take a field trip to a construction site, record observations on their handhelds, and, upon returning to the classroom, upload their observations to a desktop computer to help create a database. Students also can take the handhelds home, using them to refer to past projects and initiate new projects.

Wireless Technologies

Wireless networking technology has made it easier for schools to make computers available to their students. Easy to set up, wireless technologies are cheaper to

install and much simpler to maintain than a new wired network. Wireless technologies also bring new possibilities and innovations to classroom learning. In Oregon secondary schools, wirelessly networked note taking is used to support Hispanic migrant students who speak English as a second language (ESL). As part of the *InTime* project, ESL students attend regular high school classes along with a bilingual, note-taking/mentoring partner. Note takers and students communicate using a collaborative word processing and graphics package on wirelessly networked laptop computers. Students can read their note taker's translation of key words during class presentations. In this way, students build both English and Spanish literacy skills while they advance academically in age-appropriate courses (Knox and Anderson-Inman, 2001).

Summary

This section has briefly explored the potential of new and emerging technologies and imagined the contributions they may bring to educational pursuits. These new technologies will increase our access to information and to other people, prompting new ways of learning and new understanding. Teachers will need to ensure that students not only learn but also *learn how to learn*. This ability will be their competitive advantage in the information era.

Conclusion

This paper has offered conclusive evidence that educational technologies impact learning. From early 20th-century classroom examples, training films, and mainframe computers to *Sesame Street*, Court TV's *Choices and Consequences*, and the Apple Classrooms of Tomorrow, it has been proven that when technology is employed purposefully for defined outcomes, it can support and facilitate learning.

At the same time, learning is not a guaranteed outcome. Lack of purpose in the design of instructional content and the strategies employed to present that content in a technology-based environment can cause programs to fail. And once in the classroom, even a well-designed program can fail. With ever-increasing choices for both technology (i.e., films, video, multimedia, or Internet) and content, the need is unprecedented for thoughtful, purposeful use, carefully aligned with complementary classroom instruction and desired learning outcomes.

Knowing that educational technology does result in learning, perhaps the question we should now ponder is how we can optimize learning with technology—before the content reaches the classroom and once it is in the hands of students and teachers. The recipe for success goes beyond technology and content to the learner, the teacher, and the environment in which technology is employed.

As technology continues to advance, we have ever-increasing opportunities to present content and to create rich, technology-based environments and experiences where learning can occur. Technology can take us to new places; technology can support new connections with others around the world, which means new perspectives and experiences. Such opportunities will certainly result in many types of learning for children. The need to design new research methods and techniques that support further understanding of how people learn from technology and how educators can use technology to support learning endeavors will continue to challenge. Thoughtful attention to the content that is developed and the availability of that content to students via technology will enable educators to ensure that such opportunities benefit the learning of children in their charge.

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About the Author

Dr. James Marshall is a faculty member in the Department of Educational Technology at San Diego State University and an independent consultant to corporate business entities and school systems. He teaches graduate-level courses in instructional design, multimedia development, teaching with technology, and organizational performance.

He previously served as director of research and evaluation with Lightspan, a leading provider of curriculum-based language arts and mathematics software and Internet services for students in grades K–12. In this role, he designed and implemented a research program to determine the program's impact in schools and student homes across the country. Research efforts and results earned the program's designation as a Comprehensive School Reform Demonstration Model by the Northwest Regional Educational Laboratory in 1998. This designation was the result of the program's proven impact on student achievement and professional development — all resulting in classroom reform.

During his years with Lightspan, he also managed the design and development of more than 20 educational CD-ROM and Internet-based programs.

Before joining Lightspan, Dr. Marshall held the position of senior consultant with Andersen Consulting. Specializing in multimedia and technology-based training solutions, he collaborated on numerous projects for clients such as Novell, DHL, and Allstate, as well as internal projects directed toward Andersen Consulting personnel.

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About Cable in the Classroom

Cable in the Classroom (CIC) is the brainchild of a group of cable industry leaders, who met in 1989 to explore the best way to give back to the communities that had contributed so much to their success. Convinced that cable technology and content had enormous educational potential, they created Cable in the Classroom as the non-profit consortium that would harness the power of cable to help teachers teach and children learn.

In the 13 years since that meeting, the cable industry has changed dramatically and 97% of America's schools have been connected to the Internet. Teachers have more opportunities than ever to use a combination of excellent media, cutting-edge technologies and broadband connectivity to support teaching and learning.

The only industry-wide philanthropic initiative of its kind, Cable in the Classroom's unique contribution to schools has included, from the beginning, free cable service that provides access to commercial-free, copyright-cleared programming for taping, and now, high-speed Internet access through cable modems – a combined investment that tallies in the millions annually. Cable in the Classroom members provide rich video and online resources delivered via cable's broadband pipe. With 8500 local cable company members and 39 national cable network members, Cable in the Classroom serves 81,000 public and private schools, reaching 78% of the K-12 students in the United States.

The Cable in the Classroom focus emphasizes five essential elements to ensure quality education in the 21st century: visionary and sensible use of technologies, engagement with rich content, community with other learners, excellent teaching, and the support of parents and other adults. To translate those principles into action, Cable in the Classroom is working with prominent education advisors to find, support, and disseminate research that will guide program developers and teachers to the highest caliber content in multiple media. In addition, CIC partners with educators nationwide to create demonstration projects. These projects highlight the best uses of educational technology and foster collaboration and professional development for teachers through virtual communities and online learning.

By interacting with educationally rich content, now instantly available through new technologies, educators and students partner with Cable in the Classroom to enhance learning. Using cable modems, teachers can customize the teaching and learning experience to meet evolving standards and the ever-changing needs of individual students; support different learning styles and paces; and provide students with hands-on, interactive experiences to foster engagement.

Cable in the Classroom today, just as at its founding in 1989, continues to be driven by the absolute truth that good teaching and good learning are the most potent forces on earth. Without them, the best educational technology lies dormant. For more information go to www.ciconline.org