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ABSTRACT

Successfully integrating technology does not result from isolating and focusing solely on technology issues but rather from infusing technology into the overall school culture. Chris Dede (1998) suggests that effective integration of new and emerging technologies requires simultaneous innovations in pedagogy, curriculum, assessment, and school organization. These competing demands compound the difficulties of effectively integrating technology into daily practice. Ritchie (1996) described these needs in the form of eight variables that impact technology adoption and implementation in classrooms. Of these, a lack of administrative support is identified as the most crucial. Without administrative support, other variables such as inadequate professional development or lack of funds, are more likely to impede the effective use of technology in schools. This review is organized from the perspective of the school leader. Topics discussed in detail in this review include: vision, planning, community relationships, tools and media, integration, professional development, access, support, accountability, and ethical and legal issues. All contribute significantly to the effective use of technology to support teaching, learning, and school management. A concluding section presents a summary of key findings in each of the topic areas. (Contains 181 references.) (AEF)

Toward an Effective Use of Technology in Education

A Summary of Research

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The Institute for the Advancement of Emerging Technologies in Education at AEL

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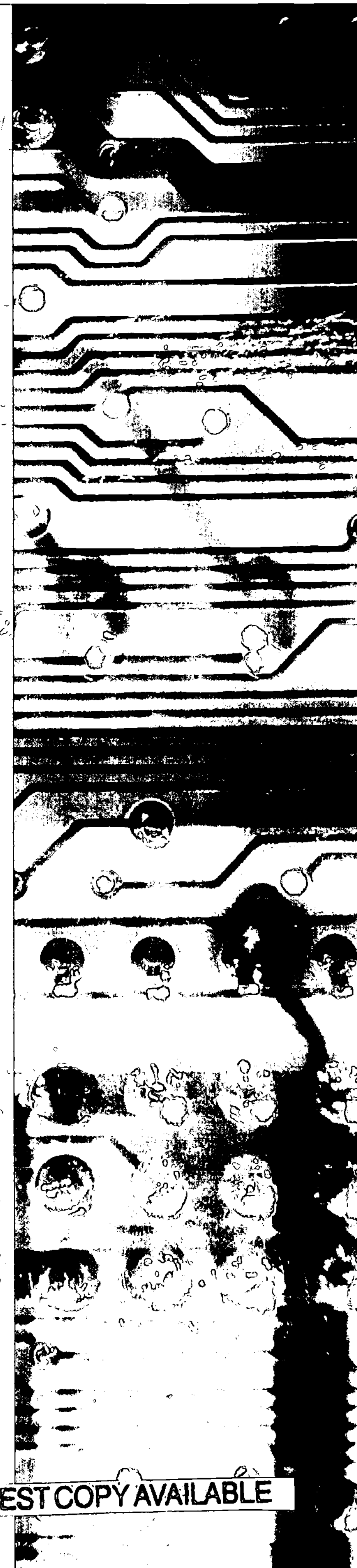

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AEL is a catalyst for schools and communities to build lifelong learning systems that harness resources, research, and practical wisdom. AEL serves as the Regional Educational Laboratory for Kentucky, Tennessee, Virginia, and West Virginia. For these same four states, it operates the Eisenhower Regional Consortium for Mathematics and Science Education. In addition, it serves as the Region IV Comprehensive Center and operates the ERIC Clearinghouse on Rural Education and Small Schools.

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Contents

Introduction

Teachers have often been blamed for failing to take full advantage of powerful technologies that would improve teaching and learning in unprecedented ways. More recently, the focus and, indeed, the blame have shifted to include teacher preparation programs, lack of technical support, inadequate professional development, and insufficient time for training (Cuban, 2001; Cuban, 1999; Groves, Jarnigan, & Eller, 1998; Kent & McNergney, 1999; Ravitz, 1998). Perhaps this gradual shift is an acknowledgment that we are finally beginning to understand the complexity of applying technology in education. Successfully integrating technology does not result from isolating and focusing solely on technology issues but rather from infusing technology into the overall school culture.

Chris Dede (1998) suggests that effective integration of new and emerging technologies requires simultaneous innovations in pedagogy, curriculum, assessment, and school organization, not just more wires and boxes. These competing demands compound the difficulties of effectively integrating technology into daily practice. Ritchie (1996) has described these needs in the form of eight variables that impact technology adoption and implementation in classrooms. Of these, a lack of administrative support is identified as the most critical. Without administrative support other variables, such as inadequate professional development or lack of funds, are more likely to impede the effective use of technology in schools. It seems reasonable, therefore, to organize and present this review from the perspective of the school leader. We believe the school leader is in the best position to balance these competing demands and to ensure technology's integration into teaching, learning, and school management. Topics presented in this review include: vision, planning, community relationships, tools and media, integration, professional development, access, support, accountability, and ethical and legal issues. All contribute significantly to the effective use of technology to support teaching, learning, and school management.

Vision

School leaders must understand how educational technology impacts students, staff, and external stakeholders. They must be able to create and communicate a vision that synthesizes the needs of diverse groups while fostering continued excellence in teaching, learning, and school management. The "wires and boxes" often mentioned refer to the limited perception of technology with which most school leaders tackle the complicated issues of effective technology integration. Effective integration requires more than buying some computers and connecting them to the Internet. Defining and articulating a clear vision is the first step in effectively integrating technology to support teaching and learning in the school community.

The Global Community

Information technologies have changed the ways we learn, work, and live, transforming the way teachers teach and students learn. Ever more new and evolving digital tools support teaching, learning, and school management. Schools must help both students and staff develop and hone information literacy skills. Many schools are tackling skill development beyond the school in the community at large.

Information technologies have had such a tremendous impact on all facets of society that schools must increasingly pay attention. An Internet connection and a Web browser are the only tools needed to enter the new global market, where information is abundant, competition is fierce, and success is often fleeting. The dynamics of information technologies have changed the ways we work, learn, and live (Dede, 1998; U.S. Department of Commerce, 1998a; Jones et al., 1995; Khirallah, 2001; Kozma & Schank, 1998; Lewis, 1999; Panel on Educational Technology, 1997; Rockman, 1998; The Classrooms of the Future, 2001; Thornburg, 1998, 2000).

David Thornburg, Director of the Thornburg Center and Senior Fellow of the Congressional Institute for the Future, suggests that the familiar "Three R's" of education be supplemented by a new set of "Three C's." Thornburg (1998) writes that the skills of communication, collaboration, and creative problem solving are all critical in this new information age. But even these Three C's are not enough, for Thornburg says other equally important skills include technological fluency and the ability to locate and process information.

Many business and education professionals agree that today's work places greater emphasis on higher-level skills, such as critical thinking and problem solving. In addition, workers in the information age must have the ability to function in collaborative teams where they may be required to develop plans, broker consensus, seek and accept criticism, give credit to others, and solicit help. These skills are important in the classroom as well. Students, teachers, and staff are called upon to develop and utilize these same skills in learning, teaching, and school management. Many educators have long emphasized these skills in their schools and classrooms; however, today educators find support for developing these skills through a variety of technologies.

The new workforce demands new literacy skills. Changes in the way business is transacted in the information economy directly impact our schools. As barriers to trade fall, the emerging global network demands a workforce prepared to compete in an integrated world economy (Panel on Educational Technology, 1997). New workforce requirements demand new skill sets from the product of our schools—students.

The U.S. Bureau of Labor Statistics (as quoted in Thornburg, 1998) lists 54 jobs with the highest growth potential between now and 2005. Of those, only eight do not require technological fluency. None of the eight currently pays more than twice the minimum wage. It is estimated that 60 percent of the jobs available at the beginning of this new century require skills currently held by only 20 percent of the workforce. In addition, the demand for workers to fill higher-skilled information technology jobs is likely to grow from 874,000 to 1.8 million in the 10 years spanning 1996 to 2006 (U.S. Department of Commerce, 1998a).

The rapid explosion of information also requires students and teachers to develop skills for managing all of this information (Thornburg, 1998). Necessary literacy skills include abilities to search and sort, analyze, evaluate, and synthesize information relevant to a particular task or need. This information must then be applied to generate new data, information, or products (Kozma & Schank, 1998). The shift to electronic commerce requires not only different skills, but often a more rigorous education in mathematics and science along with other higher-level cognitive reasoning abilities (Dede, 1998; U.S. Department of Commerce, 1998a).

Effective communication skills have also become key attributes for an information-based economy (Lewis, 1999; Lowe & Vespestad, 1999; Rockman, 1998; Stokes, 2000), as we must create, store, and distribute information through a variety of media and across countless venues. Lewis (1999) comments that as we become familiar with fast and direct feedback we can increasingly use two or more media simultaneously. Information is becoming fragmented, multichanneled, and simultaneous.

Technology not only generates a need for these information literacy skills, it also supports them. Technology can help students develop basic information skills by simulating today's work with real-life examples and reality-based experiences, and by motivating them to learn (Rockman, 1998). The CEO Forum on Education and Technology lists the skills employers most often want in students entering the current workforce: (1) students must be technologically fluent, (2) they must know how to learn, and (3) they must be able to use technology to communicate, collaborate, and support critical thinking and creative problem solving (CEO Forum, 1999). The demand for new or heightened skills in the workforce has direct implications for schools.

Systemic Reform

A new way of thinking, a new way of teaching. Papert (1993) describes an imaginary journey by two groups of time travelers: surgeons and teachers. If these travelers were to come forward in time from an earlier century, Papert surmises the surgeons would be bewildered by the changes in procedures and equipment. Not so for the teachers, who would have little trouble adjusting to a current classroom, for little has changed in approaches to teaching and learning. Peck and Dorricott (1994) put a different twist on this scenario when they consider the impact of removing all computers from schools and businesses. While many schools would feel little impact, most businesses today would find it nearly impossible to function.

The new demands on schools require rethinking the processes of teaching, learning, and school management. The U.S. Department of Education's Office of Educational Technology is doing just that. In its 2000 report *e-Learning. Putting a World-Class Education at the Fingertips of All Children,* the department set the specific goal of information literacy for all students. This report also notes that new skills do not supplant efforts to set or raise current academic standards, rather that skills necessary for becoming or remaining literate change as society changes.

The call for the systemic reform of education to meet the needs of the changing workforce has produced a wealth of discussion and debate (Dede, 1998; Honey, Culp, & Carigg, 1999; Jones et. al, 1995; Kozma & Schank, 1998; McClintock, 1995; Miller & Olson, 1995; Thornburg, 2000). In the *Report of the Forum on Technology in Education,* Levin and Darden (1999) describe camps in the school reform debate as the "re-formists" and "incrementalists." The purposes, impacts, and uses of educational technology are viewed differently by these camps, and by others who seek a more middle-ground, hybrid approach.

School leaders must understand how educational technology impacts stakeholders, whether local or more global in nature. They must be able to create and communicate a vision that synthesizes the needs of diverse groups while fostering continued excellence in teaching and learning within local schools and districts.

Dede (1998) writes that many visions of educational technology place too much emphasis on instructional activities centered on presentation and motivation. He describes this model as "kids continuously working on machines with teachers wandering around coaching the confused" (p. 203). This emphasis on presentation and motivation is not limited to classrooms with technology—it continues an antiquated model of instruction. Technology impacts what students learn and how they learn it. Using technology merely as a motivation for learning or to replicate more traditional lecture-based teaching methods grossly underestimates the impact technology can have on transforming both teaching and learning.

New roles. Systemic reform that promotes innovations requires school leaders, teachers, and students to adopt new roles. Shifts in teaching and learning prompted by the integration of information technologies may cause us to rethink our core beliefs about our roles as educators.

Student learning should be at the center of any educational model and the focus of any change efforts. In classrooms that have fully integrated technology into teaching and learning, digital tools and skills do not merely replicate traditional activities. Rather, they truly expand learning skills and pose new challenges. With technology, students can perform work that is close in scope and quality to that of more advanced scholars, such as conducting sophisticated analyses, syntheses, and simulations.

Obviously, the teacher is critical to effective integration of technology in the classroom (Ariza, Knee, & Ridge, 2000; Hannafin, 1999, Lewis, 1999). Hannafin describes the reformed role of the teacher in an open-ended learning environment as that of "knowledgeable other" and "scaffold-builder." Lanier (1997) states that teachers must go beyond being masters of subject matter to counsel students as they mature and inspire in them a love of learning. Mirroring the requirements of the new workforce, new roles for teachers de-emphasize the presentation of facts and instead ask teachers to help children learn how to think critically, solve problems, and make informed decisions (Kozma & Schank, 1998; Lanier, 1997).

Teacher professional development holds the key to successful technology efforts and should address more than the acquisition of basic technology skills. Teachers also need to learn effective integration strategies, for the potential benefits of technology use go beyond replication of existing activities and strategies, and may require teachers to rethink their underlying philosophies about teaching and their roles. It is important to emphasize that teachers also need time to reflect and adjust their teaching practices. The International Society for Technology in Education (ISTE) has taken a leadership role in developing standards for the effective use of information technology in education. ISTE has developed technology standards for students, teachers, and administrators. These standards have direct impact on schools, as many states have either adopted or adapted these standards for their use.

In institutions that have embraced technology, studies show that the teacher's importance has not lessened but that systematic use of technology actually upgrades and enhances the teacher's role (Lewis, 1999). Technology supports teamwork, curriculum development, adaptation and development of materials, action research and evaluation, and more creative management of learning environments. It can also change the nature of relationships with students by providing closer contact with individuals and small groups.

This abbreviated list from The Panel on Educational Technology (1997) suggests ways teachers may use computers and computer networks to support teaching and learning.

- Teachers can monitor, guide, and assess the progress of their students.
- Teachers can maintain portfolios of student work and prepare materials for their classrooms.
- Teachers can use computer-mediated communication tools to exchange ideas, experiences, and curricular materials; consult with experts in a variety of fields; and facilitate dialogue with students, parents, and administrators.
- Teachers may further their own knowledge and professional capabilities and can use the Internet to access remote databases and acquire educational software.

Administrators, too, play an important role in technology integration. Unfortunately, training for handling the ever-growing complexities of technology integration is often weak or nonexistent. To help classroom teachers interface between students and educational technology, administrators need ongoing training and support in understanding technology management issues, impacts of technology on educational change, and administrative uses of technology (Schoeny, Heaton, & Washington, 1999).

As the curriculum leaders, administrators provide valuable support to teachers (Coley, Cradler, & Engel, 1997; Ritchie, 1996). Ritchie lists eight variables that impact technology adoption and implementation in classrooms. Of these, administrative support is identified as the most critical, for without it one or more of the other variables, such as professional development or funding, is more likely to become a roadblock to effective integration.

The importance of school leaders in the success of technology integration cannot be overstated. Superintendents and principals must be involved in and support technology initiatives. Research has consistently found that, when school leaders are informed about and comfortable with technology, they become key players in leading and supporting technology integration activities (Coley, Cradler & Engel, 1997). Leaders should model the use of technology (Costello, 1997). In order to do so, leaders must become technology users and be involved in planning and implementing technology in their own school buildings. Serving as a technology leader may be a difficult position, especially for administrators who have little expertise and much apprehension. However, because technology initiatives depend on human dynamics, school leaders may find support by listening and responding to their teachers' concerns about technology (Fisher & Dove, 1999). The need for shared decision making and ownership echoes the findings of the seminal Apple Classrooms of Tomorrow™ longitudinal studies (Dwyer, Ringstaff, & Sandholtz, 1991.)

The Future

These many factors will influence the vision of school leaders for the integration of technology in a school or district. Gathering and synthesizing data from stakeholders will help to define and articulate that vision to drive decision making around planning, professional development, support, and assessment of and with technology. Understanding the impacts of technology and the diverse expectations of the school, community, and business audiences are key to realizing this vision.

Having technology is not enough. *Using* technology to meet the many needs of stakeholders makes it valuable. As Thornburg (2000) writes, "How you use technology in education is more important than if you use it at all."

Planning

With schools increasingly being held accountable for student achievement (Winter, 1998), parents, educators, and policymakers want to know if investments in technology are producing results. A school or district technology plan gives a voice to the vision of school leaders and the stakeholders they represent. Planning for technology has become more important now that many states and funding agents tie appropriations to the existence of a well-developed technology plan (Brush, 1998).

The Technology Planning Cycle

In a comparison of technology planning in five southeastern states, more than 90 percent of the respondents indicated their districts had written technology plans. This survey also demonstrated the importance of technology leadership. Georgia and Tennessee reported that 99 percent and 100 percent of districts, respectively, had technology leaders. The lowest percentage of districts with designated technology leaders reported in this five-state survey was 69 percent (Brush, 1998).

The technology plan document is the result of a technology planning cycle. Technology planning must become an integral part of annual budgeting, training, data gathering, and assessment of school performance (Cartwright, 1996; U.S. Department of Commerce, 1996; AEL, 2000). Results from implementation strategies spelled out in the plan create data that then feed the next round of planning and resource allocation. Although contrary to traditional budgeting practices in many school districts, a technology plan should span more than one year and have enough flexibility to accommodate new and emerging technologies, teaching strategies, and data from evaluations.

The business world, where multiyear budgeting and planning is more common, looks upon technology as a tool to increase productivity. Business models can calculate an approximate "total cost of ownership" for technology initiatives through formulas that incorporate not only expenditures on hardware and software but on increases in productivity and efficiency. These business models are difficult to adapt to school settings, however, for uses and outcomes are quite different.

A study by the International Data Corp. in 1997 (as reported in Consortium for School Networking, 1999) calculated the total cost of ownership for a school with 75 computers at $2,251 per year *per computer*, while costs for a comparably sized business were $4,517. Differences were attributed to less expensive hardware and software and less support personnel for schools, and a projected life span of five years for schools compared to three years for business. The factors that influence a district's cost calculations include support personnel, age and number of computers, number of platforms and software applications, as well as the type of network. No one formula will work for all schools.

Planning can be made less daunting by gathering proper resources—both human and otherwise—and working toward well-established goals that focus on improved teaching and learning. Keeping the learning process in mind will guide discussions, help set benchmarks, and define desired outcomes. Technology planning is more than buying "wires and boxes." Mojkowski (1999) reports that flawed planning, which focuses on installing equipment and networks and gives little attention to teaching and learning, results in problems with evaluation. This can lead to decreasing support from stakeholders.

Whether embarking upon the initial stages of planning or revising an existing plan, the technology planning cycle can be broken down into four distinct phases with unique steps, players, and outcomes. This process is described in the *Principal Connections* CD-ROM (AEL, 2000) and consists of building the technology plan, obtaining resources, implementing the plan, and evaluating the plan.

Building the Technology Plan

In the *Guidebook for Developing an Effective Instructional Technology Plan*, Dr. Larry Anderson (1996) and his students at Mississippi State University distinguish a difference between the word "plan" as a noun and "plan" as a verb. *The* plan is a document that describes *a* plan to be put into action. This document will be the road map that guides implementation of a school's or district's vision of educational technology.

Begin by gathering all key stakeholders in the planning process (Anderson, 1996; Costello, 1997; U.S. Department of Commerce, 1996). Stakeholders at the school level include teachers, administrators, representatives of the professional staff, and students. Community and business leaders should also be included, for the success of the school system affects the economic viability of the community.

When appointing faculty members to a technology committee, remember this caveat from Geoghegan (as cited in Gilbert & Geoghegan, 1995). He notes that often these committees are made up of "early adopters"—people who are ahead of the crowd in terms of skills—and this can result in overlooking the needs and concerns of mainstream users.

Including community and business leaders in planning offers many benefits. These partners may leverage financial support, become powerful advocates for school projects (U.S. Department of Commerce, 1996), and communicate with the community at large (Mojkowski, 1999). Business leaders have insights into the world of work that can help shape the vision and guide outcomes expected of the district's graduates (Costello, 1997). Community and business leaders may also offer technical support and help translate the sometimes overwhelming technology jargon into educational goals.

At early meetings, create a mission statement that incorporates data from known infrastructure and technology use and sets goals toward the unified vision of the committee (Anderson, 1996; Costello, 1997; AEL, 2000). This statement should clearly state goals and objectives for the plan (U.S. Department of Commerce, 1996). A realistic timeline should designate personnel, desired actions, and projected outcomes (Anderson, 1996, U.S. Department of Commerce, 1996).

Again, the focus of the technology plan should be teaching and learning. Rogers (1999) describes three types of goals for technology use. Technology can be used as a tool to assist learning—specifically to meet curricular requirements and content standards. Technology can also address new goals that could not be met any other way, such as creating simulations or supporting collaboration across temporal or geographic separation. These new goals may also include new learning environments and pedagogy. Technology can also assist teachers in various aspects of classroom management.

The technology plan document must also address the costs of purchasing equipment and software; developing a network infrastructure; constructing and/or retrofitting facilities; professional development sessions, materials, and substitute teachers; maintenance, technical support; and replacement of old, broken, or obsolete equipment and software (Anderson, 1996; Coley, Cradler & Engel, 1997; Consortium for School Networking, 1999; Costello, 1997; Fitzgerald, 1999; Zeisler, 1997, 1999). Networking and hardware costs will be greatest at the beginning of an initiative (Coley, Cradler, & Engel, 1997); however, costs will shift over time (Zeisler, 1997, 1999).

Many plans neglect hidden costs when planning for technology. Rooms may require retrofitting to accept network infrastructure, or they may become hotter with many computers running, which can impact HVAC (heating, ventilation, and air conditioning) costs. New technology may require new classroom fixtures such as ergonomically adjusted desks and chairs, additional outlets, and storage for portable equipment. To avoid the safety hazard of cables on floors, raising flooring or purchasing wireless hardware may be necessary (Zeisler, 1997, 1999).

After the initial investments in hardware, software, and networking, expenses shift toward personnel and include professional development to address both basic skills and effective integration strategies, as well as maintenance and support staff (Consortium for School Networking, 1999), which can be the largest ongoing financial burden (Coley, Cradler, & Engel, 1997). These shifts, combined with the need to collect impact data and revise the technology plan, require more than a one-time budget expenditure and should be incorporated into the annual budget. While a major technology effort may develop out of a one-time bond issue or major grant, the technology plan should address sustainability from the beginning (Costello, 1997; U.S. Department of Commerce, 1996; Panel on Educational Technology, 1997; Zeisler, 1999).

Obtaining Resources

The planning document outlines required resources in terms of equipment, funding, and personnel. It may also visualize a new approach to teaching and learning within the school community and require educating or informing key personnel about the expected benefits of the technology plan.

School board members must understand that technology is not a one-time expenditure but requires a line item in each year's budget (AEL, 2000). Board members must report back to the community at large and, as Mojkowski (1999) points out, stakeholders outside the school expect education technology to significantly—and quickly—impact student test scores. A well-crafted technology plan should use information gathered during the needs assessment phase to outline expected returns and describe alternative indicators of success.

A strong technology plan addresses purchasing and sustainability costs, how matching money will be sought, how the finances will be managed, and ways to address shortfalls and obsolescence (Anderson, 1996). If needs exceed budget allotments, federal agencies and private foundations may be a source for funding.

Volunteers from the local community and businesses can be important to bringing a plan to fruition. Besides helping to develop the technology plan, local people may offer expertise as well as financial support. Local support at the beginning of an initiative can grow into long-term funding if the project serves community and business members, in such ways as providing space for distance learning or technology training or offering access to infrastructure or digital reference services. Some schools involved in the Telecommunications and Information Infrastructure Assistance Program (TIIAP), now called the Technology Opportunities Program (TOP), turned potential partners into sustaining partners by offering essential resources (U.S. Department of Commerce, 1996). Many of the TIIAP schools also found that attention generated by the projects brought in new partners, building greater sustainability.

Implementing the Plan

A key aspect to every technology plan is professional development (Anderson, 1996; Consortium for School Networking, 1999; Meyer, Steuck, Miller, Pesthy, & Redmon, 1999). Ineffective or nonexistent technology training reduces the possibility of benefits from the program and can also result in a loss of investment due to equipment sitting idle. Technology instruction should encompass basic technology skills and address strategies for integration (Consortium for School Networking, 1999; Meyer, Steuck, Miller, Pesthy, & Redmon, 1999; Wolinsky, 1999).

Even though the bulk of first-year technology costs relate to building and equipment, some funds should be set aside for professional development so that new equipment may be utilized right away. After year one, professional development and technical support will take larger portions of the budget pie (Zeisler in AEL, 2000). The U.S. Department of Education (1996) recommends that school districts allot 30 percent of their technology budgets to professional development; however, observations of school districts indicate 10 percent is more common (Zeisler in AEL, 2000) and many schools do not include this essential budget item at all (Panel on Educational Technology, 1997).

The infrastructure is perhaps most often conceived as the greatest need, for it involves making decisions about equipment and network access—the "wires and boxes." Again, the vision described in the planning document that has been crafted to meet the needs of the curriculum should guide network and equipment choices.

Decisions about room or building use should be made before purchasing equipment. Room configuration is based on the intended purpose, whether it is to be used as a lab, classroom, lecture hall, or even distance-delivery facility. This purpose guides networking options, variations in flooring, wall color, furniture, placement and type of equipment, as well as lighting and HVAC systems (Carter, 1997). As few as two or three computers in a classroom can have a significant impact on spatial needs (North Carolina State Department of Public Instruction, 1995).

Networking decisions may be difficult for schools to make alone, but are an essential part of technology plans. Equipment vendors and technical consultants can be helpful, but working with these outside sources will be more productive if there is a plan that clearly defines educational outcomes, a realistic budget, and expectations regarding timelines. Do the research. Know services needed and understand some equipment options to make these relationships more positive (Anderson, 1996; U.S. Department of Commerce, 1996).

The technology plan should encompass networking within buildings as well as connections across the district and beyond. While most districts are aware of the push for Internet connectivity, especially through programs such as the Universal Service Program for Schools and Libraries, commonly called the E-Rate program, connectivity may also include phone, television, and satellite services. Wireless options, too, may be an option for network connections within a school or to the World Wide Web.

Retrofitting existing facilities is a cost that many school districts face but often fail to budget for. Retrofitting costs include wiring, asbestos and/or lead removal, new lighting, and modifications to meet the requirements of the Americans with Disabilities Act (Consortium for School Networking, 1999). Zeisler (1997, 1999) adds that many schools neglect ergonomic considerations necessary for the proper use of equipment, such as keyboard trays and appropriate seating. They may also forget the need (and the cost) for additional outlets and storage space for peripherals, notebook computers, carts, and even student backpacks that may not fit under computer desks (Fisher & Dove, 1999; Zeisler 1997). Security concerns, both on-site and on the network, increase as technology is integrated into the program.

Despite perceived needs, make software decisions only after reviewing curricular goals and matching software appropriately. Software selection should drive hardware choice (Anderson, 1996; Meyer et al., 1999; AEL, 2000). Bouie (1998) lists software options for teachers and other instructional staff that include communications tools, network management, information management, curriculum management, classroom administration, and productivity tools.

In a review of studies on school technology expenditures, the Consortium for School Networking reported that software costs consumed 4 to 10 percent of technology budgets, with 8 percent being average across schools. Suggestions for reducing software expenditures include limiting the diversity of titles across a district to reduce support and training costs, upgrading software packages across the district at the same time, controlling the installation and upgrading of software over a central network, and encouraging staff to use the same software at home as they do at school (Consortium for School Networking, 1999).

Evaluating the Plan

Remember that the planning cycle is continuous and each stage feeds and progresses into the next. Although evaluations come fourth in the cycle, they must be planned from the very beginning and take place periodically throughout (Anderson, 1996; Baker, 1999; U.S. Department of Commerce, 1996; Mojkowski, 1999; AEL, 2000). In truth, the needs assessment completed during the initial building of the technology plan is an evaluative step. In successive iterations of the planning cycle, gather data that will serve a similar purpose when the plan must be revised.

What information is important? While schools are often judged by results on standardized tests (Mojkowski, 1999), the impact of technology may not be measured so easily. The evaluation plan should be oriented to the goals and objectives developed in the planning process and should provide means to determine whether and how well these goals and objectives are being met (Anderson, 1996; Baker, 1999; U.S. Department of Commerce, 1996; Mojkowski, 1999). Measurements can include the cost of providing a service, its frequency of use, attitudes or satisfaction levels, and measures of impact such as grades and attendance records (U.S. Department of Commerce, 1996). Baker (1999) emphasizes that evaluations are planning tools that first and foremost should focus on student learning.

Most schools involved in the TIIAP program (now the TOP program) utilized two or more of the following methods to gather data: interviews, focus groups, telephone surveys, brainstorming sessions, a review of research data about the community from census records and other sources, a review of relevant state or community planning documents, or an inventory of existing technology and technological resources (U.S. Department of Commerce, 1996).

Not only should the evaluation plan outline who is responsible for completing evaluative measures throughout the cycle (Baker, 1999), it should provide for feedback to all stakeholders (Anderson, 1996; Mojkowski, 1999). Community members and business leaders may be looking for a return on their technology investment. Mojkowski (1999) suggests that rich descriptions of what is happening in classrooms and with learning opportunities are needed and can combat the call for rapid improvement on student test scores. Information about the complexity of measuring the impact of technology and descriptions of expected outcomes—besides test scores—might be necessary to help stakeholders see and understand results.

A well-designed technology plan can provide a high return on investment. The process is time-consuming and involves many players, but a strong document that begins with a vision that impacts student learning, outlines clearly stated goals, dictates roles for key players, describes funding needs and sources, and weaves evaluation into the cycle will contribute to effective integration and improved teaching and learning. Too, a successful plan serves as a model for future iterations that can incorporate new and emerging technologies and build upon a strong foundation.

Community Relationships

A school exists within several larger communities. It is geographically centered in a community with its own goals and governing practices, but that community exists within an ever-widening circle of communities that in turn impact the policies and practices of both the school and its immediate community. A school exists within education communities that include other schools, institutions of higher education, libraries, museums, and research facilities. Stakeholders come to the school as members of one or more of these communities and collaboration is essential to allow members of each community to reach their goals (Epstein, Coates, Salinas, Sanders, & Simon, 1997). A successful school system invigorates a community and both can benefit. Successful school leaders build and develop relationships within their communities—relationships that are crucial for the success of every technology initiative.

Building Community through Partnerships

In a true partnership, everyone becomes stronger. All partners bring strengths and expertise and each should also expect some benefit in return. In a school with strong community ties, teachers feel supported in their work and community members view the school as a valuable asset in terms of community development. Community members actively support teaching and learning and may volunteer time, money, or goods, or otherwise share their expertise, perhaps by serving on planning committees.

Unfortunately, the relationship between school and community is not always strong, and, as Dede (1998) notes, it seldom feels like a partnership. The school staff, working a difficult job with often inadequate resources, may feel isolated. Community members, looking for return on their investment, may appear to micromanage school operations. A community may demonstrate lack of trust when parents choose to send their children to private schools or educate them at home, or when taxpayers fail to approve school bond issues (Haynes & Comer, 1997).

What can happen when school and community build a strong partnership? Kozma and Schank (1998) describe a vision of the future that implements constructivist teaching and learning strategies supported by networked technologies. This vision extends the learning community beyond the school and encourages researchers and members of the community to participate in the education of children. This vision requires that education be a central focus of the community.

Many grant initiatives emphasize the formation of partnerships with other education institutions, business, and communities. Partnerships have always been key for schools involved in the Telecommunications and Information Infrastructure Assistance Program (TIIAP), now called the Technology Opportunities Program (TOP), (U.S. Department of Commerce, 1996). They have also been an integral part of the Technology Innovation Challenge Grants (U.S. Department of Education, 2001). Partners can provide expertise and advice on program implementation, help to develop support throughout the community, and offer financial and political support (Harris, 2000). One large district (Ingwerson, 1996) established a community awareness team of community, business, and education volunteers. This team was charged with creating an ongoing public awareness program to inform and build support for the district's major technology initiative.

There are many approaches to forming partnerships and the roles partners play can be as diverse as the community itself. Benefits, too, can be numerous and varied and can be shared by all partners. Schools seeking to develop partnerships should think through the projected relationships and be prepared to suggest returns the community might expect. The 21st Century Community Learning Centers (www.ed.gov/21stcclc/) and Community Technology Centers (www.ed.gov/offices/OVAE/CTC/) are two federally funded grant programs that support the creation of school and community partnerships— although for different outcomes. The 21st Century Community Learning Centers are extended-day programs that provide safe and supervised environments for children who might otherwise be left alone. The Community Technology Centers provide access to educational technology for students and the larger community. Both programs report benefits to students, teachers, and the community.

Benefits documented by these programs include

- Children are better prepared to succeed both in school and later in life.
- School programs better serve the unique education needs of their communities (such as improving English language skills, technology training, job skills, and employment awareness).
- School climate and attendance improve.
- Violence or criminal acts inflicted by or upon children decrease.
- Families connect with others in the schools and communities and may improve parenting skills and leadership.
- Teachers receive help in their work and support for their work outside of the classroom.

Partners often come in during the planning of technology initiatives. Community partners can offer insights into community needs and can help align school goals with community economic development goals (Rockman, 1998). Partners from business can share information about how the world of work is changing and can help align school goals with needed skills (Costello, 1997). Established partnerships can support long-term technology initiatives by developing ways to sustain these efforts after initial funding has been spent.

One successful school project began by involving the greater community in a multiyear technology planning cycle (Palestis, 1997). Community members were valuable because they brought expertise that complemented staff skills. Not only was the community involved, but it became a direct beneficiary of the planning effort, which resulted in a school-based facility to provide technology training to students and community members. The community gained an appreciation for the academic goals of the school as well as the costs of supporting those goals.

A significant factor for the success of any technology program is communication, and establishing strong external relationships can facilitate communication. Community members who participate in school-based planning and management teams have a better understanding of how our schools work and can reciprocate by providing insight into community needs (Haynes & Comer, 1997). Remember that community members may need to be informed about changes in education and how technology can help their children learn new skills necessary for work (Anderson, 1996).

The changes in education dictate changes in assessment. We need to help parents and other community members expand their knowledge of assessment. Periodic communication helps everyone understand that standardized test scores are not the only measure of academic achievement and that we need new ways to demonstrate student learning (Rockman, 1998). Key community and business leaders who support alternative evaluations of technology's effectiveness can be powerful banner carriers for school leaders.

Dede (1998) notes that research documents at least four improvements in educational outcomes from new, technology-based teaching and learning strategies. These include increased learner motivation, mastery of advanced topics, expert behavior by students, and better outcomes on standardized tests. Regardless of outcome, he suggests that the most effective means of convincing the community at large of the effectiveness of technology-based programs is to involve them in their students' education.

Using Technology to Extend the Learning Community

Information technologies can support greater school-to-home and school-to-community connections (Haynes & Comer, 1997; Kozma &

Schank, 1997; Rockman, 1998). As Internet access increases, communication barriers between schools and communities are lessened. More and more people are turning to the Internet for shopping, planning travel, finding information on hobbies and interests, and nurturing friendships through electronic communications. It is only natural that schools capitalize on this resource to provide opportunities for community involvement.

How do information technologies support greater connection between school and home? Students can do schoolwork at home. Supported by digital resources from the school and beyond, they can collaborate with peers and communicate with teachers. Parents can become more involved in their children's education and more knowledgeable about the needs of the school. Connections between the school and the rest of the community can coordinate learning goals with community goals and help to integrate education into daily life (Kozma & Schank, 1998). The Benton Foundation (1998) suggests that information technologies can help our communities work together to solve social problems relating to poverty, housing, crime, and health concerns.

Teachers are beginning to use the Internet to communicate with parents. In a 1999 survey of public school teachers, Rowand (2001) found that 25 percent of the teachers surveyed reported using a school computer to communicate with parents, while 19 percent reported using a home computer for this type of contact. Teachers report communicating with colleagues at a much higher rate, with 50 percent using school computers and 48 percent communicating from home.

Haynes and Comer (1997) add that networked technologies have encouraged schools to broaden their mission and begin providing services for the entire community. Some schools develop Technology Nights that encourage parents, community members, and business people to witness the results of technology programs first hand (Anderson, 1996). America Links Up (www.getnetwise.org/americalinksup/) is sponsored by a coalition of educators, nonprofit organizations, and corporations and seeks to provide children with a safe and rewarding online experience through a campaign of public awareness.

Many schools go beyond demonstration to provide technology instruction and access to members of the community through school-based facilities (Bouie, 1998; Palestis, 1997). School staff or technology-savvy students present lessons and offer technical support. Such Community Access Centers (CACs) are used most by people who lack access at home or work (U.S. Department of Commerce, 1999). CACs help community members build basic technology skills while getting a glimpse into the necessity of technology-based instruction for their children. Educating parents and other community members through CACs also opens lines of communication and helps schools develop a broader base of support.

Tools and Media

School leaders face tremendous challenges of stretching budgets and reformulating plans as they try to best utilize the advances in technology. At the same time, they must evaluate tools, media, and processes. The time needed to effectively employ new tools and media in pursuit of valid learning experiences is often interrupted by changes in hardware and software, incompatible systems, upgrades, and newer models. In a survey of U.S. states, 31 state-level technology directors revealed that technology funding during the 2001-2002 academic year is equal to or greater than funding in 2000-2001, teachers are integrating the Internet into instruction, and most responding states have technology accountability plans in place (Roberts, 2001). In this climate of increased spending, intensified accountability, and rapid technological growth, school leaders need to be aware of issues surrounding new tools and media and their potential value to schools.

Large percentages of technology budgets continue to be allocated for hardware purchases. In fact, Market Data Retrieval (2001) reports that 66.7 percent of schools' technology spending goes to purchase hardware. Schools find many more types of hardware and services available. Recent developments include alternative Internet access devices, wireless Internet and Web, broadband, handheld digital devices, and e-book readers, to name a few (Bishop, 2000).

Teachers often begin computer integration by using software applications that approximate familiar, well-structured classroom activities (Sheingold & Hadley, 1990). Different categories of software are associated with the different levels of adoption identified by the Apple Classrooms of Tomorrow (ACOT) research (Dwyer et al., 1991) and the Concerns-Based Adoption Model (Hord, Rutherford, Huling-Austin, & Hall, 1987). Productivity tools are best suited to replicate seat-based work and complete traditional student activities, namely research papers and reports. Word processing applications are the most familiar productivity tools; others include spreadsheet and database applications. Productivity tools and drill-and-practice software—similar to traditional flashcards—are the most commonly used applications in the earliest stages of software integration (Baker, Gearhart, & Herman, 1993; Dwyer et al., 1991; Sheingold & Hadley, 1990).

Greater experience with technology enables teachers to incorporate a wider variety of software applications and approaches, thereby enriching learning opportunities for a larger population of students. These approaches move beyond the typical classroom activities of lecture-based presentation and seatwork and shift toward learner-centered rather than content-centered lessons. These new activities, supported by curriculum-based software and research tools, allow for greater individualized, creative, and interdisciplinary project-based activities.

Studies show that various software types produce vastly different educational outcomes. Developmental software has been shown to provide significant benefits to young children. Haugland (1997) describes developmental software as open ended, providing learners with more control. Flexibility in learner control can actually determine the scope and sequence of an application. Benefits of developmental software include increasing users' intelligence, verbal and nonverbal skills, long-term memory, manual dexterity, and problem-solving and conceptual skills.

When used properly, computers may be important tools for improving student proficiency in mathematics (Welinsky, 1998). Proper use includes the selection and application of appropriate software. In a study of the relationship between uses of educational technology and educational outcomes, Welinsky found that using computers for drill and practice negatively impacted the academic achievement of eighth-grade students. Furthermore, he found that using computers for learning games (academic games) was positively related to the academic achievement of fourth-grade students. Clearly, software type is a factor when considering the effectiveness of computers as learning tools.

Internet use was not common in earlier technology adoption studies, such as the reports on the ACOT program. Increased expenditures, easier access to the Internet, and the explosion of the World Wide Web have allowed teachers to expand beyond packaged software to include this resource as an instructional tool. How do teachers approach integrating Internet use in their classrooms? How does this differ from previous findings? Ravitz (1998) recently investigated instructional Internet uses by teachers experienced with this newer networked technology. In terms of use, 75 percent of the participants reported that all students used the Internet in their classes; 70 percent reported spending at least an hour each week developing their own Internet skills or participating in Internet searches for instructional materials—clearly delineating an experienced sample. Technology use once again reflected technology experience.

Participants who scored higher on use were more likely to report that improved Internet access in their classrooms would help "a lot." Ravitz suggests that more frequent users might take greater advantage of improved access, opening them up to a possibly wider variety of instructional Internet uses. Of the teachers polled, 86.4 percent indicated their students benefited from using the Internet; 56.7 percent indicated their students *greatly* benefited from this use.

Cattagni and Westat (2001) concluded that by the fall of 2000, 98 percent of all schools were connected to the Internet, a finding that suggests Internet-based media will have a prominent place in classrooms for the foreseeable future, though how this may look in practice is unknown. The dot-com crash of the past year had a considerable impact on the educational software market, which has shrunk by more than 22 percent in one year to only $454.6 million. Of this, the K-12 portion of the market is considerably less (Molenda and Sullivan, in press). In the current business climate it seems likely that many companies offering Web-based solutions for schools will merge, form alliances, or in some cases cease to exist, creating a difficult challenge for decision makers (Levinson & Grohe, 2001).

Lack of appropriate software. The lack or limited availability of software—especially that designed to support the curricula teachers must cover—makes it difficult to justify putting even a reasonably affordable computer on every desk (Graham, 1997; Rogers, 1999). The importance of quality educational software cannot be understated. Dublin, Pressman, and Woldman claim that "diversity among students (racial, socioeconomic, cultural, learning styles, academic achievement, gender, disabilities) is uniquely accommodated by top-notch software" (as cited in Eastman & Hollingsworth, 1998, p. 272). It is unlikely, however, that software publishers will keep pace with the demand for quality educational software. For example, more than 184,000 copies of the popular game Diablo II were sold on a single day in July 2000 (National Public Radio, 2000b). Unlike software games, where popular titles can top $100 million in sales, educational software is far less profitable, resulting in limited availability of appropriate titles (Teacher's Pet, 1994). Software selection, then, becomes an increasingly important skill for teachers to learn. Teachers must know their system requirements, instructional goals, and software expectations to make informed decisions (Rader, 1997).

A great deal of information is available regarding the disparity between the increased volume of recent technology purchases in our nation's schools and the apparent lack of use for instruction of these new purchases. In summarizing changes in education hardware and software purchases over the past decade, Sivin-Kachala and Bialo (1999) conclude hardware expenditures in schools increased 99,900 percent between 1991 and 1998 ($2.1 million to $2.1 billion). In this same period, software expenditures increased only 37 percent ($598 million to $822 million). Schools have invested in hardware, but the software that provides functionality to these materials has not been purchased. It is also widely noted that teachers do not use technology for instruction despite recent expenditures (Cuban, 1999; Ely, 1999; Kent & McNergney, 1999).

Software use at school does not necessarily reflect a teacher's entire exposure to technology. Computer use is definitely growing. A recent poll indicated that 81 percent of respondents under age 60 have used a computer either at home or at work (National Public Radio, 2000a). The rise in ownership of home computers has increased student and teacher access to technology (Robertson, Calder, Fung, Jones, & O'Shea, 1997). A 1997 survey of educators, computer coordinators, and school librarians by Educational Market Research (as cited in Charp, 1997) indicated that 72.2 percent of the respondents used the Internet at school and/or home. In a recent survey (Benson, Peltier, & Matranga, 1999), 80.6 percent of the respondents reported using word processing at least weekly, and 78 percent indicated owning a computer at home. Susan Eastman and Helen Hollingsworth (1998) suggest that

> those teachers who have most successfully utilized computers in the classroom usually have equivalent technology in their homes. But even if they have the hardware, many teachers lack the software for their curricula as well as the time to develop original presentations for their classes (p. 259).

There are more than 8.6 million instructional computers in classrooms across the nation (Anderson & Ronnkvist, 1999). This enormous financial investment in educational technology, along with the national movement toward greater accountability in public education, exerts tremendous pressure on educators to produce results. As the accountability momentum builds and technology expenditures increase, educators will be expected to demonstrate more frequently how they use technology to improve student achievement. Linking software use to student achievement demands effective technology integration, which, in turn, requires highly confident teachers who are skilled in effective pedagogy, hardware and software use and support, classroom management, and content knowledge. As Shade (1999) suggests, "The most critical decision a teacher can make is that of software selection. After all, a computer is little more than plastic and electronic circuitry until software is loaded" (p. 276).

Integration

As the ratio of students to instructional computers drops and access to the Internet increases in the nation's classrooms (Smerdon, Cronen, Lanahan, Anderson, Iannotti, & Angeles, 2000), it is unlikely that either teachers or students will be able to continue to work and learn without integrating technology to some degree into their daily activities. Unfortunately, when computer technologies are adopted, the learning about technologies often supplants learning content with the help of technology (Goldman, Cole, & Syer, 1999). Integration is not simply buying a computer or connecting to the Internet—supplying the "wires and boxes." Integration demands the incorporation of technology as an integral tool in the learning environment that seamlessly supports teaching and learning (Cuban, 1998; Schwab & Foa, 2001).

Learning with Technology

In its report to the President, the Panel on Educational Technology (1997) made two high-level strategic recommendations that it believed to be of utmost importance. The first is that the nation's schools focus on learning *with* technology, not *about* technology. This recommendation enforces the concept of technology as an important tool and that simply acquiring technology-related knowledge and skills is not enough. The second recommendation is that schools emphasize content and pedagogy, not just hardware. This may require some schools to rethink the role and use of technology in their schools and focus attention on the potential of technology to help achieve goals pertaining to education reform efforts. New teaching and learning strategies may be necessary to promote the development of higher-order reasoning and problem-solving skills (Panel on Educational Technology, 1997; Schmidt, Sasser, Linduska, Murphy, & Grether, 1999).

Dockstader (1999) described the many facets of technology integration when writing about the teachers of the twenty-first century. She notes that integration can include learning about technology but that students should do this by applying computer skills in meaningful ways. Software should allow students to use computers flexibly, purposefully, and creatively. Integration also requires having the curriculum drive technology use, not vice versa. She summarizes integration by stating that it is organizing the goals of the curriculum and technology use into a "coordinated, harmonious whole."

Further emphasis on the learning environment finds support from Lewis (1999), who writes that considering the needs of the learner is one way of addressing the role of technology. Some of these learner needs include explicit information, recognition of achievement, flexible access to resources and support, opportunities to practice skills and apply knowledge, feedback on performance, and choices in their learning.

School leaders play a prominent role in promoting the effective integration of technology in their schools. While some leaders come to accept that some of their teachers may have greater technology expertise, they can continue to learn and use these teachers as resources (Caverly, Peterson, & Mandeville, 1997). School building administrators are faced with many other issues beyond technology integration, however, and find themselves ever more accountable to taxpayers, boards of trustees, central office administration, and parents; and there is a great need to increase the efficiency and productivity of these administrators (Benson et al., 1999). Understanding how technology can impact teaching and learning is an important step for school leaders faced with such issues of productivity and accountability.

The Impact of Technology

Technology is changing the ways teachers teach and students learn. Technology can open up the classroom and provide opportunities for students and teachers to share, discuss, and exchange ideas with larger communities of learners. Technologies can open up the more traditional classroom and provide the opportunity for students and teachers to share, discuss, and exchange ideas with larger communities of learners (Honey & Hawkins, 1999). Technology can enhance and invigorate education and make schools more exciting and richer learning environments (CEO Forum, 2000). How does this expanded opportunity translate into improved student achievement? The answers may not be as concrete as a score on a multiple-choice test, but evidence does exist to indicate that technology positively impacts teaching and learning.

Research documents that effective technology-enhanced pedagogical strategies can result in at least four kinds of improvements in education outcomes: increased learner motivation, mastery of advanced topics, students acting as experts do, and better results on standardized tests (Dede, 1998). While student scores may rise on conventional achievement tests, these results do not occur immediately, and both teachers and students must move beyond learning about technology to effectively integrating technology into the learning environment. Also, conventional achievement tests do not measure the full impact of technology (Dede, 1998).

In reviewing benefits culled from the Apple Classroom of Tomorrow studies, Kosakowski (1998) reports that students explored and represented information dynamically and in many forms—communicating effectively about complex processes. Students were more confident and became more socially aware. They worked well together but were also independent learners and self-starters. Students involved in this long-term, technology-intensive program used technology routinely and appropriately. These students also demonstrated increased writing skills, a better understanding and broader view of math, the ability to teach others, and greater problem-solving and critical-thinking skills.

Peck and Dorricott (1994) give a "top 10" list of reasons to use technology. A few examples from this list include that students learn and develop at different rates, and technology can address some of these differences. Technology can foster an increase in the quantity and quality of students' thinking and writing skills, and it can create opportunities for students to do meaningful work. It can also nurture artistic expression.

Technology can help teachers and students explore content in greater depth—moving beyond knowledge and comprehension to application and analysis of information. Finding, synthesizing, and creating information are important skills for the current information-rich world. Technology skills, too, are important and the development of these skills should not take place in isolation, but applied throughout the learning process (Dockstader, 1999).

Teachers who have faced the integration hurdle may have to reconsider some of their underlying philosophies about teaching. These changes could manifest themselves outwardly in the form of new teaching strategies, activities, and forms of assessment, but this may take some time (Bruce, B., 1999). In their efforts to help teachers enrich classrooms through the incorporation of multimedia, Wise and Groom (1996) found that teachers felt multimedia had the biggest impact on the teachers themselves. They found the material visually stimulating, that it could present more detail about subjects, and that it actually simulated bringing the real subject into the classroom.

Mann and Shafer (1997) found that the success of technology is strongly related to teacher enthusiasm, initiative, and sense of improvement. Teacher interest in technology was highest when they had access to enough hardware, used applications teachers cared about, and received relevant training. These researchers found that high school teachers were often the most positive about technology's ability to contribute to both school reform and their own work, but that some of the strongest supporters of technology were teachers involved in special education, career education, and adult education.

It is important to stress that the mere presence of wires and boxes is not enough to obtain the potential rewards of technology. Bouie (1998) lists several factors that must be present before technology can have a positive impact. These include providing students with significant access to technology and resources on a regular basis, providing teachers with professional development activities that include effective integration and communication training, and having education leaders who propagate an environment that integrates technology as a valued component of learning.

Stages of Integration

Teachers follow similar stages of technology adoption as they first learn about the technology and then begin to incorporate it into their teaching and learning. Early activities tend to mirror current teaching activities with which the teachers feel comfortable (Sheingold & Hadley, 1990). As comfort and proficiency improve, teachers may begin to use technology for instruction in novel ways or create activities that better capitalize on the capabilities of the technology.

The pivotal, longitudinal project, the Apple Classrooms of Tomorrow (ACOT) began in 1985 and has provided a wealth of information regarding teacher attitudes, practices, and integration behaviors when using technology. Early reports from this project identified a five-stage continuum of technology integration that evolved at all of the project's sites (Dwyer et al., 1991). This evolutionary process consists of five stages: entry, adoption, adaptation, appropriation, and invention. Whether or not broken into distinct stages, a similar evolution of teaching and learning with technology is found in several sources, such as Sheingold and Hadley's (1990) finding that teachers begin with technology that replicates familiar activities. Similar findings are reported in a later evaluation of the ACOT project (Baker et al., 1993) in which teachers immersed in technology chose resources and based pedagogical decisions upon subject area rather than the technological resources that were available.

Word processing, problem-solving, and drill-and-practice applications are often a first step in incorporating software into the instructional process because these applications replicate common seat-based classroom activities, reinforce material already being taught, or provide special opportunities for particular groups of students. However, the lower-order thinking skills addressed by these software applications have garnished negative connotations for instruction, with drill-and-practice software specifically demonstrating little (Haugland, 1997) or even a negative relationship to academic achievement (Wenglinsky, 1998). As technology experiences grow, teachers are able to incorporate a wider variety of software applications and approaches that provide richer learning opportunities for the larger population of students. These new approaches often shift toward learner-centered rather than content-centered lessons, which replace the traditional classroom activities of lecture-based presentation and seatwork with more project-based and collaborative activities. The more familiar types of activities, which may be addressed by simple word-processing and drill-and-practice applications, give way to the need for curriculum-based software and research tools, which often allow for greater individualized, creative, and interdisciplinary activities.

Technology integration takes time. Consequently, teachers must be given the time to learn and time to practice using their new skills. The

National Information Infrastructure Advisory Council, a former inter-agency advisory council to the federal government, prepared an analysis of time it takes teachers to reach the various ACOT skill levels (Mehlinger, 1997).

Sheingold and Hadley (1990) summarize that teachers appear to master many practices and approaches within five to six years of teaching with computers. Dwyer, Ringstaff, and Sandholtz (1991) noted that some of the teachers in the ACOT project moved into the fourth phase of appropriation—incorporating student-centered, project-based instruction—in their second year. While no fixed schedule of development may be applicable to every instructional setting, there is strong research base to support an evolutionary process of teaching and learning with instructional technology. This evolution of practices carries with it the adoption of software types.

Supporting Change

The Concerns-Based Adoption Model (CBAM) (Hord et al., 1987) was developed at the University of Texas at Austin and has been successfully utilized to implement change in settings across the world. The CBAM is based on the premise that the single most important factor in any change process is the people involved and affected by the change.

SKILL STAGE	DESCRIPTION	TIME REQUIRED
Entry	Teachers typically learn the fundamental aspects of using new technology, including the basics of configuring hardware and software.	None
Adoption	Teachers concern themselves with ways to use the technology to support traditional instruction.	30 hours
Adaptation	Teachers integrate technology into existing classroom activities. The emphasis is productivity. Students use word processors, databases, and some graphics programs to create familiar products of instruction.	45+ hours training, 3 months experience, just-in-time support
Appropriation	Teachers begin to develop new approaches to teaching and learning that make the most of the technology available to them. A teacher's mastery and skill level have developed to enable the creation of new learning activities not possible without the technology.	60+ hours training, 2 years experience, just-in-time support
Invention	Teachers no longer try to adapt instruction to technology but adjust their fundamental perceptions of instruction. Teachers who reach this stage reflect on the actual craft of teaching, and their classroom strategies may become quite different.	80+ hours training, 4-5 years experience, just-in-time support

Evaluations of an innovation that do not consider whether the change was implemented correctly or to what degree the change has taken place can lead to distorted results. From their years of research and experience with implementing the CBAM, the developers note the following about change:

- Change is a process, not an event. Change occurs over time, often several years, and cannot be "handed off" or implemented like turning a key or a switch.
- Change is accomplished by individuals. Change is often conceived and presented in ambiguous, impersonal terms. In reality, change affects people and the way they act, think, and believe. Successful innovations must consider the role of individuals.
- Change is a highly personal experience. People will react to change differently and their actions will not all be the same.
- Change involves developmental growth. People express their reactions to change in terms of their own feelings and skills.
- Change is best understood in operational terms. People will relate to change in terms of what it means to them.
- Change facilitators should address questions in concrete, practical terms. The focus of facilitation should be on individuals, innovations, and the context. Change will only occur when people alter their behavior. Notions about the rate of change, strategies and procedures, and even what success means may alter as behaviors change.

The CBAM is not prescriptive but provides a framework for facilitating change. The model was originally conceived and tested in numerous schools and can be adapted to any type of innovation, such as integrating technology. The model notes that successful change management requires that a skilled facilitator be designated and ready to support the change effort. Training is required to fully implement all facets of the CBAM as a "change facilitator."

Similarities Between ACOT and CBAM. While the CBAM is not technology-specific, it can certainly be applied to schools' efforts to integrate technology into their curricula. There are several elements common to both the CBAM and the ACOT studies that are of particular importance to those undertaking an innovation. These similarities are listed below for review.

- **Individual focus.** Both ACOT studies and CBAM emphasize the importance of the individual in the success of any innovation. While many innovations are described in impersonal, global terms, the change that is required is individual. Without the growth of individuals no innovation will succeed.

- **Developmental stages.** Both describe a series of stages in which the user first applies an innovation by replicating known methods and materials. Successful progression through the innovation arrives at a stage in which participants have thoroughly incorporated aspects of the innovation to the point that a new synthesis of ideas, methods, and materials becomes the starting point for a new generation of innovation. This is the innovation stage in the ACOT studies.
- **Ownership.** Both emphasize the importance of the participants' sense of ownership in the integration of the innovation. Participants will be challenged to grow and may be forced to rethink beliefs and philosophies. Without buy-in from the participants, the innovation will not be implemented as desired.
- **Time.** Innovation takes time. Schools and districts that yield to pressures to implement innovation and expect results for their stakeholders within a year will be disappointed. Both the ACOT studies and CBAM note that innovations take years to show impact. The average time for teachers in the ACOT studies to reach the appropriation stage is two years, while teachers who reach the invention stage may take at least five years to progress this far.
- **Focus for evaluation.** To truly demonstrate the impact of an innovation the evaluation must first consider the stage of adoption of the individual participants and the innovation as a whole. Evaluations that do not consider how the innovation is being used will yield to misleading results.

Overcoming Barriers to Integration

Schools may face many barriers prohibiting the effective integration of technology. Fortunately, whether these barriers are physical, such as lack of hardware and software, or less tangible, such as attitudes and perceptions, many schools and districts have already faced some of these problems, and their experiences can suggest strategies for overcoming these barriers. Following are five major barriers many schools have faced and some strategies that may help overcome them.

Purpose. One of the most significant barriers to effective integration of technology is the perception that in many schools technology is still seen as an "add on" rather than an integral part of the curriculum (Charp, 1997; Rockman, 1998). Some teachers may use computer work as a reward for students who have finished other work or for good behavior. Others may view time in the computer lab as release time or neglect to coordinate technology skill development with curricular goals.

The purpose of technology use should be clearly defined in the school or district's technology plan (Anderson, 1996; U.S. Department of Commerce, 1996; Kozma & Schank, 1998). A well-developed plan will outline concrete, time-based goals and outline strategies for achieving these goals, including funding, training, and benchmarks for ascertaining whether the goals were achieved. Overcoming the view of technology as a frill can be achieved through clear communication of the vision presented in the plan by key school leaders. School leaders should demonstrate the value of technology in their own daily work and ascertain the needs of their staff through a variety of data-gathering methods, including but not limited to classroom observation.

Dockstader (1999) describes how teachers in the Jerome School District successfully approached technology integration through a seven-step process. Teachers began with a single core area, then decided what technology skills were most appropriate for this area. Teachers selected a single lesson or unit that could be enhanced by technology, often choosing easier projects at the beginning. Teachers developed that lesson or unit using a software package or other appliance until they were comfortable with it, then taught the lesson. Teachers evaluated the lesson, focusing on what went well and what went wrong, and then refined the lesson for the next time they taught it or applied those skills to a new lesson or unit. A similar method of piloting lessons and developing prototypes of best practices has been successful elsewhere (Lowe & Vespestad, 1999).

Training. Lack of professional development is often cited as the most common barrier to effective technology integration (Charp, 1997). Training that develops basic technology skills may be important but is not enough. Teachers must also receive training focused on effective integration techniques that support the goals of their curriculum (Charp, 1997; Kozma & Schank, 1998). This need for training is not limited to in-service teachers, as many pre-service teacher candidates leave teacher training programs with insufficient technology skills (Schmidt et al, 1999). Additional factors that impact training decisions include finding release time and substitutes, both of which also carry a cost burden. Another barrier is the lack of training geared to the unique demands of school leaders.

Reflecting 20 years worth of lessons learned in professional development, the National Staff Development Center (NSDC) developed guidelines that relate to the appropriate application and integration of educational technology. These guidelines propose a constructivist approach to professional development and suggest that teachers and administrators collaborate in such activities as action research, conversations with peers about the basic nature of instruction, keeping journals, and projects that involve family and community members in student learning (as cited in Coley et al., 1997). Improving opportunities for training of administrators is addressed by the Apple Classroom of Tomorrow Teacher Development Center Project. Administrators are encouraged to attend the program with a teacher team, and they must commit to providing release time and daily planning time for teachers as well as time for teachers to reflect on their work. Administrators also increase staff awareness through public acknowledgment of their teachers' efforts (as cited in Coley et al., 1997).

Support. Many teachers are still at the early stages of the integration continuum. These stages require support in terms of both pedagogical and mechanical help. Many teachers rely on more advanced or experienced peers—early adopters who have worked through some common problems. Easy-to-read, print documentation is another need (Charp, 1997) that may be harder to come by as software and hardware publishers continue the trend of online help. Novice users may prefer more traditional print to the new industry preference for online help. As schools continue to develop Web-based components for teachers, students, and the greater education community, the need for round-the-clock support becomes greater. Cartwright (1996) notes that while many thought the problems associated with technology would dissipate as more teachers became fluent users, these problems have not gone away. Schools must pay attention to continuous training and support for faculty, staff, and students.

A variety of support strategies are presented by Coley, Cradler, and Engel (1997). The advanced or experienced teachers mentioned earlier may actually serve as a valuable resource for other teachers. These master teachers could be trained specifically for the purpose of acting as resources or mentors to colleagues. One school (Lowe & Vespestad, 1999) found the structure of teams to be a successful peer resource model. Expert personnel from libraries or volunteers from business, parent, and student groups may also be available to support teachers. Teacher resource centers can provide both pedagogical and technical help and, as teachers become more familiar with logging on to the Internet, they can reap the benefits of online tutorials and telementoring. One school district (Hurst, 1994) found that dedicating one room to continuous inservice helped boost teacher confidence and positively impacted integration. This quiet room was loaded with equipment, software, and manuals and afforded teachers the opportunity to experiment in a private setting.

Time. Time places finite barriers on technology integration because teachers may already feel their time has been maximized without trying to learn new teaching strategies or new software. Time cannot be created and, when having to juggle schedules, teachers may resort to tried and tested methods and materials. Training takes time and if training is going to be supported beyond a few one-day sessions, release time may be required. Time can also be wasted by inefficient technology use—either by teachers or students. New adopters may also need additional planning time not only to build and practice technology skills but to develop effective strategies to incorporate their new skills (Fisher & Dove, 1999). Inexperienced teachers often underestimate the time and complexity of integrating technology. Novice users may be excited to try new technology-supported lessons, but early efforts usually result in an emphasis on the technology and little on content learning. Many teachers already feel the pressure of too little time to cover the required curriculum. This is what Goldman, Cole, and Syer (1999) refer to as the "technology/content dilemma."

From their experiences helping and observing teachers integrate technology, these researchers found structuring the technology-supported activities to be key in promoting content over technology. In a technology-supported math activity, they helped the teacher structure an activity that encouraged students to notice, name, and reflect on math concepts encountered in their lessons. These researchers also helped teachers structure informal conversations with students during activities by slowing down and spending a few minutes with student groups. Students not only demonstrated desired content outcomes but felt they did so during an engaging activity that had real-world applications due to the technology use.

Supporting teachers with increased planning time or release time is encouraged (Coley et al., 1997; Lowe & Vespestad, 1999) but may require educators and policymakers to reconsider some of the traditional constraints of the school structure, such as the bell schedule, the school year, or the requirements of contact time. While new models may not work in all settings, the most successful programs are often those that have developed effective technology plans (Gustaferro in Norman, 1999; Hurst, 1994). Finally, once having reached a certain level of proficiency, technology can help solve rather than create the time problem by helping teachers and staff perform their duties more efficiently and by freeing up time for instruction or professional development (Kosakowski, 1998).

Funding. Insufficient funds affect not only hardware and software purchases but can impact staffing as well. The shortage of teachers proficient in technology may make it difficult for some districts to attract such teachers (Schmidt et al, 1999). The draw for technology workers may also draw the most qualified teachers away from a school district or from teaching altogether.

The cost of technology is often attributed to hardware and networking costs, but too often schools do not budget sufficiently for hidden costs that may compound their problems, such as retrofitting buildings, replacing obsolete or broken hardware and software, professional development, and maintenance and support personnel (Consortium for School Networking, 1999; Zeisler, 1997; 1999). Computer prices are dropping, but few schools have yet to reach the recommended ratio of five students per computer or the optimal ratio of one student per computer (Graham, 1997). Schools also face many decisions regarding network configuration. While broadband access requires substantial funding, many schools do not have the infrastructure to support connections through phone lines.

While there is no one answer to the funding question, the best strategy is planning (Anderson, 1996; Coley et al., 1997; Consortium for School Networking, 1999; Costello, 1997; Zeisler, 1997, 1999). A well-designed planning document created by key stakeholders not only describes desired learning outcomes but also designates components (e.g., hardware, software, training, and support needs) and suggests methods for funding these components. The planning document does not actually guarantee procurement of funds, but it can suggest steps that must be taken to guarantee sustained funds throughout the program's initiative, whether those steps require a major bond issue or funding through outside sources.

Professional Development

One of the most crucial elements for increasing the return of investment on technology expenditures is professional development (Bailey & Pownell, 1998; Consortium for School Networking, 1999; Norman, 1999). While professional development costs can be measured in terms of trainers, materials, and substitutes necessary for release time, neglecting this critical step may bear much higher costs. Failing to implement an effective, ongoing professional development initiative will severely limit a school or district's ability to achieve its technology goals (Consortium for School Networking, 1999; Panel on Educational Technology, 1997). The U.S. Department of Education recommends that districts set aside 30 percent of their technology budgets for professional development, but research indicates that expenditures for this vital component fall closer to 10 percent (Zeisler in AEL, 2000).

The Costs of Professional Development

Without effective professional development paired with adequate support, teachers may not ever effectively integrate technology into their teaching and learning activities (Bailey & Pownell, 1998). The amount of technology training teachers receive directly impacts the way technology is used in the classroom and therefore directly affects how and what students learn (Norman, 1999). The desire for effective integration of technology puts an increased emphasis on the necessity of professional development and calls for rethinking methods and approaches used in past training efforts.

Ultimately, professional development should directly impact how students learn and should positively impact student achievement. This places the emphasis of the training on people, not technology. In one national study (National Education Association, 1996), 73 percent of the teachers surveyed indicated that their primary motivation for participating in professional development activities is to improve student achievement.

What Is Good Professional Development?

Regardless of the topic or skills addressed, successful professional development should employ several consistent elements, which are not unique to technology professional development. Good professional development decisions fit with goals and objectives that support the school's mission. Professional development should meet the specific needs of the teachers, and activities should emphasize curricular application within a framework of skills development and should be supported through adequate resources—especially time. Teachers need time to build skills, to become familiar with new content and materials, and to practice new skills in their content areas and learning activities. Support for these activities should include adequate practice and follow up as well as an evaluation component.

Many researchers and practitioners agree that successful professional development gives participants opportunities to collaborate and communicate with their peers. Peer coaching is often more effective than the lecture format and many schools find success in following a train-the-trainer model that allows individuals to receive training or attend conferences and then return to the home school and share their new knowledge and skills.

Consideration should be given to the characteristics of adult learners as a whole and to educators specifically. Adult learners have a more developed set of beliefs than children about what is and is not appropriate. Educators have often developed strategies and methods that they feel work best for them and may be slow to change (Tally & Grimaldi, 1995). Bailey and Pownell (1998) also suggest that professional development programs must meet human needs in order to be effective. Based on Maslow's Hierarchy of Needs, the authors indicate that successful programs will meet basic needs of every individual and that equal emphasis will be placed on both human needs and technological concerns.

Educators weigh new methods, materials, and theories against personal experiences and their existing knowledge base. They evaluate the value of the new data in comparison to both their own and their students' learning needs. Programs that reflect this understanding offer educators the opportunity to experiment and reflect in a safe setting, as well as opportunities to collaborate and discuss ideas with their peers (Fulton, 1996). Norman (1999) provides eight components of effective professional development programs as they relate to technology. Notice that while these components target educational technology programs, they could just as easily describe effective professional development in areas that do not involve technology.

- Involve all stakeholders and create a shared vision.
- Set relevant and realistic goals.
- Develop a strategic plan and budget.
- Assess and capitalize on all resources. (Consider people a primary resource.)
- Link professional development to teacher needs and learning objectives.

- Model best practices.
- Provide teachers with time, incentives, and ongoing support.
- Establish a system for periodic review, assessment, and adjustment.

Skeele (1999) offers some practical tips for presenting professional development for teachers that have relevance to administrators, as well. She acknowledges that it is important to know the expertise and interest level of participants. Session topics should address participant needs—especially daily classroom needs. Examples should present things teachers can use in their classrooms, and the introductory session should include an opportunity for teachers to put their new knowledge into practice. Helpful supporting materials include an agenda, a list of helpful tips, and complete price and product specifications that include hardware configurations (Skeele, 1999).

Educators have been charged with revising approaches commonly referred to as "one-size-fits-all" workshops in which teachers are offered an overview of concepts or skills irregardless of their level of proficiency, and given little opportunity for practice and follow-up (Fulton, 1996; Hurst, 1994; Jackson, 1999; Tally & Grimaldi, 1995). One survey reports that 46 percent of courses designed to help teachers integrate technology are offered as half-day workshops, and 79 percent of these workshops focus on specific hardware or software or Internet usage (Panel on Educational Technology, 1997). These approaches are inefficient and ineffective—especially in regard to technology integration (Fulton, 1996).

Teachers report that technology professional development has been positive but too short and infrequent (Hurst, 1994). The U.S. Department of Education reported that only 20 percent of public school teachers say they feel very well prepared to integrate educational technology into the classroom (as cited in Norman, 1999). The one-size-fits-all approach ignores both adult developmental processes (Tally & Grimaldi, 1995) and the well-documented stages of technology adoption through which most teachers progress (Dwyer et al., 1991; Jackson, 1999). Due to the rapid changes in technology, ongoing professional development must occur. Caverley, Peterson, and Mandeville (1997) suggest that a more productive model to combat the rapid evolution of technology is to educate teachers and administrators in the use of technology so they may later apply their training with new technology.

There is widespread agreement for the need for this type of focus on integration rather than basic skills development (CEO Forum, 1999; Coley et al., 1997; Kozma and Schank, 1998; Tally & Grimaldi, 1995; Thornburg, 2000). Time is an integral component of development. Teachers need time to build skills, become familiar with software and content, and to practice integrating technology into their content presentation and learning activities. Teachers will need the opportunity to discuss technology with their peers and may benefit from ongoing mentoring and consultative support. The commitment to this scope of professional development should be addressed early—in the school or district's technology plan (Panel on Educational Technology, 1997).

In their 1999 report, the CEO Forum makes several recommendations for professional development. Among these are that: (1) schools of education should prepare teacher candidates to effectively integrate technology, (2) current teachers and administrators should be proficient in technology integration, and (3) systems should be developed to reward effective technology integration. These recommendations call for standards for continuing education to support effective technology integration, proficiency standards for teachers and administrators supported by long-term professional development, and matching content standards to appropriate technology integration components.

Professional Development Models

Rather than describing specific models, the following is a presentation of trends in professional development models. These trends may be observed individually in models or may be found in combination. All may be applied or adapted to help develop successful professional development programs.

Development centers. Technology training centers are found both in K-12 settings as well as higher education (Candiotti & Clarke, 1998; Fons & Wyler, 1995; Hurst, 1994; Shapiro & Cartwright, 1998). They can be extensive and offer a full spectrum of training opportunities, staff versed in technology integration and instructional design, and a plethora of hardware and software to introduce educators to new and emerging technologies with possible application in their classrooms.

While staff development opportunities supported by such a center are optimal, not all centers are used for the presentation of structured sessions. Noting that teachers sometimes felt uncomfortable or intimidated demonstrating their developing technology skills, one school dedicated a single, small room to continuous technology inservice (Hurst, 1994). This room was filled with all the hardware and software available throughout the school as well as accompanying peripherals, workbooks, and manuals to encourage experimentation in a safe, nurturing environment.

Another school established a demonstration and training site that also serves as a lending center for hardware and a preview center for software (Fons & Wyler, 1995). This center can support a variety of professional development presentation options, such as vendor-supplied training, train-the-trainer sessions, collaborative professional development, and interdisciplinary unit development.

Train-the-trainer and collaborative models. The unifying factor of these models is the reliance on human resources. A variety of strategies may be found in either model to generate continued support and the range of human capital is sometimes surprising.

Designed with the intent of duplication or modification, one district (Schmidt et al., 1999) developed a framework for professional development where educators work collaboratively to design effective models of technology use that facilitate meaningful learning in classrooms. Participants work with preservice and inservice teachers through mentoring programs, courses, focus groups, and providing support. Approaches used to optimize training time and effectiveness include group inservice sessions followed up by demonstration of software by trainers in actual classrooms, and partnering of preservice candidates with inservice teachers from two to four hours per week.

Described as a "generational" model, another district (Caverly et al., 1997) uses strong early adopters to help future generations of teachers effectively integrate technology. These early, strong adopters attend a "technology boot camp" for three weeks during the summer focusing on integration in interdisciplinary, thematic units. Once classes began, these first-generation integrators met throughout the year to receive additional training as well as create and share further interdisciplinary units. Peer support and evaluation helped this group become experts in their own right. The cycle continued as each first-generation teacher returned to boot camp, but as a mentor to two new integrators rather than pupil. As the number of teachers exposed to this training grows, these teachers not only train other teachers but also become a valuable resource in their own schools during the school year.

Modeled after the successful projects, such as Generation www.Y, some schools have also capitalized on one of their largest human resources, their students (Lowe & Vespestad, 1999). Technology often increases student interest and motivation and some districts have found that these young adopters can help teachers grappling with building basic technology skills and applying them to effective integration practices. Even elementary and middle school students can help with basic troubleshooting, routine maintenance, and can even support teachers in their professional development efforts. One school uses students in collaborative teams and has found success with student-led staff inservice efforts. These same students also help community members build their technology skills in the evenings (Lowe & Vespestad, 1999).

Using technology to support professional development. Much like other leadership principles, technology itself may be utilized to support successful professional development activities. Telecommunications applications allow teachers to interact, take courses, and access research (Coley et al., 1997).

Web-based professional development can also offer greater flexibility in terms of times of service as well as pacing. Some costs such as substitutes, travel costs, and problems associated with scheduling may be avoided. Components that may be offered during Web-based professional development include online lectures, opportunities for chat and threaded discussions, tutorials, resources cataloged in searchable databases, and video components for modeling (Jackson, 1999).

One Web-based model (Rodes, Knapczyk, Chapman, & Haejin, 2000) supplements field-based activities in the participants' own classroom with distance-based elements. Technology is introduced slowly. The program has demonstrated success by beginning with technologies that teachers readily become accustomed to, such as fax machines and e-mail. Technology skills build to include Web-based conferencing.

Telecommunications are not the only technical application of professional development, as some districts utilize technology to support local efforts. Electronic portfolios are a popular application of technology that helps demonstrate skill acquisition while allowing for individual creativity. Portfolios have been described as the most appropriate and authentic means to chronicle and demonstrate professional improvement over time (Wiedmer, 1998). As teachers become more familiar with the possibilities of technology, telecommunications tools, electronic portfolios, and other applications will undoubtedly find a greater foothold in professional development activities.

Access

To optimize the return on technology investments, school districts should make sure all students and teachers have easy, reliable access to technology that supports learning goals. While some school districts work to improve access within the traditional school day and setting, many schools and their surrounding communities have acknowledged the importance of increased technological skill and access for all community members and are working to expand them beyond these traditional boundaries. Schools, libraries, and community centers are quickly becoming the frontline of technology access for all residents (Bagasao, Macias, Jones, & Pachon, 1999).

Where Do We Want to Go; Where Are We Now?

Rockman (1998) describes four barriers to learning that can be reduced or removed through increased access to telecommunications and technology. These include the barriers of geography, economic status, individual learning styles, and special needs. Thornburg (2000) describes how increased access to information transforms things we already know and requires lifelong learning. He comments that "one of the great promises of educational technology is that it makes available to all what was once only available to a few (p. 5)."

Jones, Valdez, Nowakowski, and Rasmussen (1995) help us understand access through four indicators. They say a technology-enhanced program has high access when it has connectivity, ubiquity, interconnectivity, and is used equitably. These authors define *connectivity* as the ability to access rich resources within and beyond the school. Technology is considered *ubiquitous* when hardware and software are readily available to students and teachers for problem solving, communication, collaboration, and data exchange. *Interconnectivity* occurs when students and teachers communicate and collaborate in diverse ways using technology. Finally, when technology gives everyone access to rich and challenging learning opportunities, its use is considered *equitable*.

Access to technology is often discussed as a ratio of students to computer. In *Getting America's Students Ready for the 21st Century*, the U.S. Department of Education (1996) stated that, to make technology a viable instructional tool, all students—including students with disabilities—must have easy access to modern multimedia computers. The Department's goal for the year 2000 was five students for every modern multimedia computer in every school. According to Williams (2000), we may have realized that goal. In a representative sample of 1,000 public schools, the national ratio of students to instructional computer was 6:1 in 1999, virtually the same as the previous year.

School access to the Internet continues to increase. The percentage of schools connected to the Internet has increased from 35 percent in 1994 to 95 percent in 1999. The percentage of instructional classrooms connected to the Internet increased from 3 percent to 63 percent in the same five-year period. The ratio of students to instructional computer connected to the Internet improved from 12:1 in 1998 to 9:1 in 1999. Demographic characteristics influenced variations with this national average. Medium-sized and large schools had more students per Internet computer (9:1) than small schools (6:1); urban schools had more students per Internet computer (11:1) than rural schools (7:1); and schools with the highest concentration of poverty had the greatest number of students per Internet computer (16:1) compared to schools with the lowest concentration of poverty (7:1) (Rowand, 2000).

In the revised National Technology Goals, the U.S. Department of Education (2000) report no longer discusses student-to-computer ratios but speaks in terms of universal access: all students and teachers will have access to effective information technology in their classrooms, schools, communities, and homes (Levin & Darden, 1999). Additional priorities support the effective use of technology by teachers; students being technologically literate and responsible; and emphasis on research, development, and evaluation as the breeding ground for the next generation of educational technology applications.

The CEO Forum, a group of the nation's top business executives, emphasize the need for universal access in their 2001 report, *Key Building Blocks for Student Achievement in the 21st Century* (p.29). President George W. Bush's (2001) pledge to "Leave no child behind" is evidenced by his promise to loosen restrictions in the FCC's E-Rate program and propose $400 million in new spending over the next five years for the Education Department to research ways that technology can be used to boost student achievement. The new national goals call for access beyond classrooms and include the greater community.

The goal of universal access incorporates more than students and teachers. Universal access holds that learning can and should be supported through the richness of networked technology not only in schools but wherever learning can take place—libraries, museums, community centers, and the home.

Universal access. Support for universal access is widespread (Cartwright, 1996; Jones et al., 1995; Panel on Educational Technology, 1997; Thornburg, 2000). Many believe that universal access will provide equal learning opportunities for all students—or at least equal access to learning resources. Indeed, some suggest that providing all students and teachers access to technology resources, perhaps through the use of low-cost portable computers, can support a paradigm shift in the way computers are used in schools, a shift described as early as 1980 by Seymour Papert (Robertson et al., 1997).

Included in the concept of universal access is access for learners with special needs. Planning for special needs students includes those with disabilities and gifted and talented students (Anderson, 1996; Benshoff & Lewis, 1992; Howard 1999). Students with disabilities receive learning support from a variety of adaptive technologies. Such hardware and software tools may include speech synthesizers, larger monitors, touch screens, scanners with scan-reading software, voice recognition systems, speech output devices, keyboard of various sizes, trackballs, joysticks, and Morse Code sip and puff switches (Anderson, 1996). The Center for Applied Special Technology (CAST) (www.cast.org/) promotes the concept of universal design, which endorses the creation of learning environments that provide alternatives for students, teachers, and parents with different backgrounds, learning styles, abilities, and disabilities. Universal design does not suggest that one solution will work for everyone, but that the learning environment must remain flexible to include as wide an audience as possible.

Dede (1998) reminds us that focusing on access and literacy alone won't take us to educational equity. He suggests the real issue in equity is empowerment. Information technology can empower dispossessed groups to achieve their goals. Dede also notes that, from a historical perspective, innovative information technologies often widen inequities when first introduced. The resulting segregation by commodity is reduced only after the technologies mature, drop in price, and are widely adopted. This segregation of the technology-rich and the technology-poor is often called the "digital divide."

The digital divide. This term most often refers to access to the Internet; however, the concept is much broader and its origin is often attributed to the cost of technologies (Revenaugh, 2001). While many communities are familiar with home computers, mobile phones, and Internet access, many low-income neighborhoods have had little exposure to devices now considered "low-tech," such as laser scanners at supermarkets and automatic teller machines (Benton Foundation, 1998). The divide can be deepest in low-income neighborhoods that do not have an adequate telecommunications infrastructure. The lack of Internet access and basic phone service leads to the greater problem of making an area less attractive for businesses that demand a robust telecommunications infrastructure (Benton Foundation, 1998).

The U.S. Department of Commerce (1995, 1998b, 1999) has been tracking and reporting on the digital divide for several years. Its most recent (1999) report announced that access to computers and the Internet has increased dramatically in all demographic groups and geographic locations. At the end of 1998, more than 40 percent of all American households had a computer and 25 percent had access to the Internet. Phone penetration has increased, as well, especially among those who were less likely to have phones previously—young and minority households in rural areas.

Whites are more likely to have access to the Internet from home than are Blacks and Hispanics from any location—home, school, or community centers. Blacks and Hispanics are also less likely to have Internet access at home than are Americans of Asian/Pacific Islander descent.

Income and education levels also affect access. Regardless of income, rural Americans are less likely to have Internet access than urban dwellers. In households with incomes of $75,000 or more, the divide between Whites and Blacks actually decreased considerably between 1997 and 1998. If this continues to hold and the price of access decreases, the disparity between race and access to the Internet may lessen even more (U.S. Department of Commerce, 1999).

A recent survey by National Public Radio (NPR, 2000a) provides similar findings concerning computer use and ownership. Income and education affect computer use. Americans under age 60 with annual incomes under $30,000 or with a high school education or less are least likely to use a computer at either home or work. There exists a 17 percent gap in home-computer ownership between low-income Blacks and low-income Whites; however, these differences virtually disappear in high-income households, much like the Internet access findings previously mentioned.

This poll also found some good news. Computer ownership is up among groups previously identified as less likely to be computer owners. First-time computer owners in the past two years under age 60 are more likely than long-term owners to be low income and to have a high school education or less (NPR, 2000a).

Schools are an important ingredient for improving access and reducing the digital divide for school-age children. Despite the disparity of access to computers at home, this survey found that 55 percent of White children, 60 percent of Black children, 56 percent of students from high-income households, and 59 percent of students from low-income households now use computers at school (NPR, 2000a). This success in providing access to technology has prompted leaders to encourage schools, libraries, community organizations, and agencies to work together to ensure that entire families have access to technology.

As access to computers and the Internet increases, a different issue gains importance. The Children's Partnership (2000) has expressed concerns that much Internet content has little value to many of the low-income and underserved populations that have recently gained access. Current barriers to use of content include lack of information about their communities, literacy barriers that are shared by 44 million American adults who do not have adequate reading and writing skills, language barriers to the 87 percent of the documents on the Internet that are in English, and a lack of support for content and interaction in culturally diverse venues (Lazarus & Mora, 2000).

Reducing the divide. Communities may choose from several strategies for reducing the digital divide. Schools, libraries, and community centers can serve as important community access points to computers and the Internet (Bagasao et al., 1999; U.S. Department of Commerce, 1999). Rockman (1998) further notes that some communities have after-school programs that provide instruction and support as well as access, and some schools provide children from disadvantaged families the opportunity to have a computer at home through loan, subsidized purchases, or low-cost computers that have been reconditioned.

To help address inequities of Internet content, the Children's Partnership (2000) suggests communities start to address their information concerns by exploring their own community values and developing their own content and community resources. More global strategies include supporting communities as they develop more effective online content through finding resources, marketing the content, and carrying out research and development.

Finally, technology itself may be used to address factors that have promoted the disparity of access. As part of an effort to address the problems of chronic poverty, technology may be used to facilitate the exchange of ideas vital to building community. Technology can help social service agencies reach a broader audience and can empower individuals and groups by supporting new venues of public discourse. New and emerging technologies could support communities in their endeavors to combat problems related to housing, crime, and health concerns, among others (Benton Foundation, 1998).

The school infrastructure. The school network can be a powerful agent in support of education reform (Carlitz & Hastings, 1995). A network that provides easy access to finding, creating, and storing information resources will allow students and teachers to produce materials, collaborate, and share resources. A network can help end the isolation of remote students and teachers and can promote equity of access to online resources. The success of such a network will depend upon ease of access, flexibility, and affordability (Carlitz & Hastings, 1995).

The school network should integrate data, voice, and video components and should extend to every school and library in the district

(Anderson, 1996). Such a network may also provide distance learning opportunities for students as well as professional development opportunities for staff. After all, professional development will be required to achieve maximum benefit from the network investment (Honey et al., 1999).

Kozma and Schank (1998) suggest installing the highest speed Internet connection that can be afforded and investigating the possibility of a wireless network—at least a wireless local area network, which can integrate support services for handheld, laptop, desktop, and even wearable technologies. Satellite and wireless broadband services (fast Internet connection) have potential for rural areas, as the distance has no affect on cost (National Telecommunications and Information Administration, 2000).

Connectivity to and between schools, libraries, and other education centers means little if there is no useful content. Unlike print resources, resources stored in digital archives offer opportunities for students and teachers to mold and even create content and to express understanding of content in multiple formats. Honey and Hawkins (1995) describe the potential of digital archives to achieve four goals: provide information anytime in anyplace, provide multimedia information in a variety of visual and aural formats, allow students and teachers to personalize or customize how they access and represent information, and radically enhance collaborative activities by reducing the barriers of geography, organizational hierarchy, and time.

Honey and Hawkins (1995) further describe three key design considerations for digital archives. They suggest that the publishing industry is dominated by a mindset that discourages inventiveness in students and teachers and makes products that are "teacher proof." Digital content, however, allows experimentation in selection, format, and presentation. Teachers can use these resources in ways that make sense to them. This concept of teacher ownership is the first important design principle proposed by the authors.

In order to increase student engagement, the second design principle, designers of digital archives must consider the cognitive, social, and emotional stages of development of the potential users. The authors suggest that the students and teachers themselves are the best sources for assessing these developmental levels. Finally, to make the best use of digital resources, teachers and students need to be able to build their own approaches to searching and organizing archived materials. Indexing schemes that work well for a scientist or researcher may not be useful in a classroom (Honey & Hawkins, 1995).

Choosing the most appropriate network connection may be difficult, and the options all bear different price tags. Kozma and Schank (1998) suggest installing the highest speed Internet connection that is affordable, but some options aren't available everywhere. Lower bandwidth connections cost less than faster, more powerful broadband options, but the lower bandwidth involves a tradeoff in terms of time required to access materials and the complexity of information that may be transmitted (Consortium for School Networking, 1999).

Rural areas lag behind urban areas in broadband availability. However, rural towns are more likely to have broadband connections than residents outside of towns. These "last mile" households pose a difficult problem for broadband deployment. Urban areas enjoy such broadband options as digital subscriber line (DSL) and cable modems, with cable modems the most widely deployed service. As mentioned, satellite and wireless access may be options for some rural areas (National Telecommunications and Information Administration, 2000).

The solution to the access puzzle is unique to each district. The well-defined technology plan will describe desired learning goals that will help each district make decisions concerning options and funding to bring its vision to reality.

Support

"I need help." We've all said it when we started using a new piece of hardware or software. And, while we joke about not being able to program a home VCR, schools and districts that are integrating computer networks and the dizzying array of related software and hardware can't laugh away technical problems. They need help, and the issue of support goes beyond keeping the "wires and boxes" up and running.

What Is Support?

Support-related issues fall into two categories: technical support and pedagogical support. Technical support keeps equipment and the network up and running, and provides sufficient software and supplies so that hardware can be used as intended to support teaching and learning. But every dollar spent on purchasing and maintaining infrastructure is in jeopardy if teachers do not receive adequate pedagogical support to build technology skills and craft technology-supported learning environments and experiences. These new activities and the student outcomes they produce may look different than those of traditional learning activities and will need a supportive environment in which to evolve.

Lack of support presents many barriers to adopting emerging technologies into education (Rogers, 1999). These may include the scarcity of technical support in the form of user services and staff necessary to maintain components of the technology infrastructure. Something as minor as the lack of toner cartridges for printers can have major impact on teachers who have planned activities dependent upon them. A lack of institutional supports such as administrative encouragement and funding can also inhibit technology adoption. Attitudes toward technology and its uses also help determine what technologies and strategies are employed (Rogers, 1999). To be successful, school leaders must also provide pedagogical support to teachers faced with integrating technology into their classrooms.

Do not assume that there will be few technology problems just because equipment is new (Fisher & Dove, 1999). Cartwright (1996) observes that early adopters of computers in schools expected training and support to be short-term problems that would go away as computers became widespread. Computers and their peripherals are much more sophisticated than their educational technology predecessors, such as record players and televisions, and teachers should not be expected to solve complicated equipment malfunctions or maintenance problems. Schools and/or districts must provide maintenance, either in-house or through outside contracts (Fisher & Dove, 1999). Equipment downtime can result in frustration, leading some teachers to avoid technology use (Consortium for School Networking, 1999).

Knowing that they have support can encourage teachers to continue with integration despite their inability to solve technology troubles (Wolinsky, 1999). A good start is to incorporate support issues in planning. Anderson (1996) lists the following points to consider:

- Financial support to purchase hardware and software
- Financial support for the infrastructure
- Training for faculty and staff members
- Incentives for participation in training programs
- Elimination of teachers' routine tasks to make time to help peers and students
- Technical support to maximize the use of the hardware and software
- Consultation and advice on safety and related legal issues

Costs. Support and professional development will be the largest ongoing costs (Coley et al., 1997). These two components can reasonably be considered the most critical components in the effective infusion of technology, but often receive less attention than hardware, software, and network connectivity (Bailey & Pownell, 1998). The difficulty of anticipating the need for consumable technology supplies—such as toner cartridges, paper, storage materials, and software upgrades—makes it hard to project these costs at the beginning of new technology initiatives. Remember that as new technologies are adopted, the quantity and variety of these supplies increases (Fisher & Dove, 1999).

Many schools and districts struggle with funding technology support personnel (Bushweller, 1996; Sturgeon, 1999; Zsiray, McRae, Liechty & Gibbons, 2001). Finding and retaining such personnel can also be difficult. Teachers note that many support personnel are paid salaries much greater than instructional personnel. Some schools report difficulty finding support personnel who have the interpersonal skills to work in a school environment. The increasing demand for technology support personnel means there is also high turnover (Fisher & Dove, 1999). While these difficulties must be considered, once technology support personnel are found, they will be assets (Candiotti & Clarke, 1998).

Maintenance and replacement. Given the investment required to provide a significant number of computers for instructional purposes, it's unfortunate that their useful life is only three to five years (Consortium for School Networking, 1999). Total-cost-of-ownership models for businesses are usually calculated on replacing computers on a three-year cycle, but schools may be able to stretch this to five years. Some schools may be expected to extend the life of computers beyond five years, but this may actually negate an attempt at savings as older machines often require greater maintenance and support costs.

Inadequate long-range planning can seriously compromise future equipment use (AEL, 2000). While a purchasing and replacement cycle of five years is recommended, schools traditionally use one-year funding cycles, not long-range budgets, and funding cycles of a single year are typical. Because schools or districts may not be able to make long-term budget commitments, many experts recommend that schools purchase computers with the most memory and processing power they can afford (Consortium for School Networking, 1999).

Older equipment may be designated for less intensive work. For example, computers that can still run word processing software are useful for text-based projects. Older computers can also be used as "dumb" terminals for proprietary software (such as inventory and cataloging software used in libraries and media centers) or can be designated as single-use machines for individual software titles (AEL, 2000). Older computers may actually need more support as they become less reliable. Fees might also be charged to dispose of computers (Consortium for School Networking, 1999).

Anderson (1996) lists planning considerations that may reduce maintenance costs in the long run. Routine monitoring of equipment and basic preventative maintenance can reduce many major equipment failures. When buying equipment, purchase common replacement parts at the same time. Maintenance contracts may give a false sense of security. Read contracts and warranties closely and know what is and is not covered. Make sure equipment is accessible in case repairs are necessary, and keep maintenance logs for all equipment. These logs can provide assessment data when further purchasing decisions are required. Some vendors lease computers with maintenance support and replacement built into the contract. Include basic maintenance in training sessions—for both staff and students—and find outside volunteers as a resource for free or low-cost service (Anderson, 1996).

Pedagogical support. Teachers who integrate technology face several new challenges. They must be able to select appropriate software, develop strategies to integrate the technology into their activities, and assess students in new ways (Fulton, 1996; Panel on Educational Technology, 1997). Collaborative work supported by groupware, telecommunications software, and multimedia applications demands both new teaching and new assessment skills. Teachers need sustained pedagogical support in order to integrate them successfully.

Teachers may explore several avenues to find this support—observing peers who are successful with new technology, consulting with experienced mentor teachers, and establishing a dialogue with other teachers facing the same challenges. Estimates say that the typical teacher will take three to six years to fully integrate educational technology into teaching and learning; ongoing changes and advancements in technology may ensure that this process is never fully complete (Panel on Educational Technology, 1997).

One distance education program incorporated pedagogical support by pairing instructional designers with teachers to help them match required course objectives and skills to appropriate software and teaching methods (Shaeffer & Farr, 1993). The instructional designers also monitored the course electronically and responded to teacher concerns as they arose. This coaching of teachers has made significant impact on retention and return rates for both instructors and students. Teachers appreciate the support and report changes in their teaching. For many, this was their first opportunity to discuss pedagogy with a colleague.

Support strategies. The most-often recommended support strategy is the designation of full-time support personnel (Bete, 1998). The number varies widely however, with schools reporting a ratio of support personnel to other staff as high as 1:500. This compares to reports from business of a 1:50 ratio (Consortium for School Networking, 1999). The number of support staff will depend on the actual number of workstations, as well as the variety of platforms, operating systems, and software applications.

Observations from the Telecommunications and Information Infrastructure Assistance Program (TIIAP), now called the Technology Opportunities Program (TOP), indicate that clear definitions of staff roles will help in making the best match between the requirements of the school or district and the qualifications of candidates (U.S. Department of Commerce, 1996). These programs teach us that support staff should be able to interact and communicate comfortably with all staff and be able to explain technical skills in plain English for staff members at the early adoption stages. As mentioned, support staff turnover should be expected but the effects of turnover can be countered by training staff in several jobs so the school can continue to function without serious interruption. One school district suggests categories to address during interviews of potential support personnel. These relate to technical expertise, understanding of technology in an instructional environment, professional development, and Internet knowledge and experience (Smith, 1997).

When a designated support person cannot be hired, many districts rely on teachers with technology experience (Consortium for School Networking, 1999; Panel on Educational Technology, 1997; Smith, 1997). Unfortunately, this can create problems if the teachers are not given time and supplies to complete both their teaching and support duties. Without training, these individuals may also have limited impact. This solution has been called by some teachers the "unenviable position of providing troubleshooting and stopgap maintenance" (Fisher & Dove, 1999, p. 5).

Some schools capitalize on the interest and motivation of students or outside volunteers. In one example (Lowe & Vespestad, 1999), student interest at a middle school supported the formation of a computer club despite the limited technological proficiency of sponsoring teachers. Building on student interest in basic programming, gaming, and troubleshooting, the program has blossomed, and members provide classroom technical support as well as some technology training of teachers during the day and community members in the evening. Generation www.Y (207.225.234.197/genwwwy/) was originally a recipient of a Technology Innovation Challenge Grant from the U.S. Department of Education and has become a model program for partnering students with teachers to provide technology support. Begun in Olympia, Washington, Generation www.Y now has partner schools all over the nation.

As with many challenges of technology integration, technology itself can offer some solutions to the support dilemma (Fulton, 1996; Panel on Educational Technology, 1997). Computer-mediated communication tools allow teachers to create, share, and evaluate materials online. Teachers can serve as mentors or simply share stories throughout a school, district, or across geographic boundaries. Videotapes and broadcast video options, such as teleconferencing and streaming video, allow teachers to observe successful peers who have faced integration challenges. One such Web-based program, classrooms@work/tools@hand, gives teachers a way to hear, see, and gain from others' experiences (www.netc. org/ classrooms@work). Robust online environments can support professional development opportunities in basic maintenance and troubleshooting skills as well as advanced pedagogical strategies—often with flexible scheduling and in the convenience of teachers' homes.

Accountability

While many business leaders, community members, and policymakers support educational technology initiatives, these same stakeholders increasingly demand evidence of technology's impact on teaching and learning (Kozma & Quellmaiz, 1995). Investors and supporters want to know what kind of return they are receiving on their investments. However, technology integration can foster learning environments and activities that help students attain skills not easily measured by traditional methods of assessment.

Assessment and evaluation are related concepts in the realm of accountability. In this instance, assessment is defined as the measure of student skills and knowledge using technology. The interest in using technology for student assessment, whether for demonstrating efficacy of day-to-day classroom instruction or for large-scale, high-stakes testing online, will have direct impact on most schools. Evaluation refers to measuring the impact of technology on schools—the degree to which it is effectively integrated into the curriculum. Evaluation questions focus primarily on the program level and weigh the costs of staff time and capital outlay against the projected benefits in student achievement. Most schools demonstrate accountability through measures of student achievement.

The Need to Evaluate Technology

The need for new models. "Evaluating the impact of technology must be based on an understanding of its role in the teaching and learning process" (Rockman, 1998, p. 3). Kozma and Quellmaiz (1995) agree that traditional forms of assessment often fall short when evaluating the impact of educational technologies. These researchers call for new criteria, measures, and methods of collecting data when the use of different technologies and pedagogies complicates assessment. Projects that attempt to address variables other than student learning, such as improving teacher knowledge and skills or including new classes of participants in the education process, tax traditional assessments even more. Consequently, no single evaluation design can be used in all situations.

While few educators are professional evaluators, they must still make decisions about technology use and methods. Bertram Bruce (1999)

57

presents several factors that require new evaluation methods, which include:

- Users adopt technology at different rates. Early adopters tend to be more adventuresome and knowledgeable about technology, but evaluations must reflect the whole community of users.
- New technologies are often not isolated entities and must be evaluated as components of larger, more complex systems.
- Technologies change rapidly, and standards and strategies for use may become outdated even as evaluation methods are being developed.

Additional factors include new roles teachers and students assume when using educational technology, scale effects, technical characteristics, and the limitations of access (Bruce, B., 1999).

In a review of district technology plans, Mojkowski (1999) noted that many plans propose evaluation indicators that are based on measuring student test results, while others are linked to the technology infrastructure, such as counting the number of computers and Internet connections. He suggests that more valuable indicators are changes in student learning opportunities, engagement in learning activities, and attention to higher order or complex thinking. He contends that districts should focus on developing a deeper understanding of the impact technology has on students' experiences.

Further reasons for new evaluation models include the need for administrators to use data-driven decision making to build support for their programs (Benson et al., 1999), to evaluate how teachers are guiding student interactions in technology-based activities (Caverly et al., 1997), to combat high attrition rates in distance education settings (Dominguez & Ridley, 1999), and to evaluate potential problems early and guide further evaluation efforts (Quiñones & Kirshstein, 1998).

The National Forum on Assessment has developed seven principles for student assessment systems. The primary purpose of assessment is to improve student learning, and assessment for other purposes should support student learning. Assessments should be fair to all students. Communications about assessment should be regular and clear, and assessment systems should be reviewed and improved regularly (National Forum on Assessment, 1995).

Demonstrated outcomes. Some stakeholders still hold schools to traditional measurements, such as standardized test scores, as indicators of impact. Many argue that such measures are not reliable indicators of the impact of technology (Coley et al., 1997; Ellett, 1998; Heinecke, Blasi, Milman, & Washington, 1999; Kosakowski, 1998; Kozma & Quellmaiz, 1995; Lanier, 1997; Mojkowski, 1999; Rockman, 1998; Wiggins, 1997). If faced with providing evidence that technology can impact student achievement positively, the literature does offer support.

Coley, Cradler, and Engel (1997) summarize findings from numerous studies on the impact of technology. Drill-and-practice and computer-assisted instruction (CAI) have demonstrated positive gains in student achievement, and there is evidence that a variety of specific applications lead to improvements in student performance, student motivation, and teacher satisfaction. At least a dozen meta-analyses involving over 500 studies have demonstrated positive impact of computer-based instruction.

Students in all subject areas and at all levels also usually learn more and at a more rapid pace using CAI (Kosakowski, 1998). CAI can be more cost effective in achieving equivalent gains from strategies such as tutoring, reduced class size, or increased instruction time. Kosakowski also reports that students using CAI feel greater self-esteem and feel more successful, motivated to learn, and self-confident.

Mann and Shafer (1997) conducted one of the largest studies on the effects of educational technology. The preponderance of their data—quantitative, qualitative, longitudinal, and anecdotal—suggests that increased access to technology "supports, facilitates, and encourages student achievement" (p. 22). When they studied five counties in New York, they found that the percentage of high school students passing the math state Regents exam increased by an average of 7.5 percent, and those passing the English state Regents exam increased by an average of 8.8 percent. They also found that 42 percent of the variation in math scores and 12 percent of the variation in English scores could be explained by the addition of technology in the schools.

Some researchers (Heinecke et al., 1999) suggest that analyses of the relationship between technology and student learning depend upon how both student learning and technology are defined. These researchers accept studies revealing a positive relationship between certain types of technology and increased student learning—if student learning is defined as the retention of basic skills and content information as demonstrated through standardized tests. However, if student learning goes beyond the simple relationship between a student, a computer, and a test to include engaging in critical and higher-order thinking and problem-based inquiry, then research has been less successful in demonstrating that technology supports these more advanced behaviors. Performance-based assessments supported by technology must be developed to measure the greater impact on student learning (Heinecke et al., 1999).

Grades and test scores are not the only measures of success. Improvement can take many forms and include the performance of teachers, administrators, and other staff; delivery of programs and services to students, parents, and the community; and ability of the school community to accomplish its mission (Stronge, 1997).

Teachers trained in the use of multimedia noted additional outcomes not necessarily tied to grades, such as increased student interest and greater student attention. While some students became excited by the multimedia, others were merely entertained. All were more alert and attentive, however. One surprising positive outcome was reported. Teachers often encountered difficulties or frustrations during their daily use of technology, having to solve minor technical difficulties or resort to alternate plans. Observing their teachers facing and overcoming these difficulties, students learned lessons about problem solving and decision making and also learned that setbacks in technology are common (Wise & Groom, 1996).

Honey, Culp, and Carrigg (1999) believe that the impact of technology on teaching and learning must be understood in context. These researchers present several lessons learned, including the roles that specific technologies can play in the education process and technology's powerful ability to connect schools with the greater community. They suggest that research strategies and questions must be defined in terms of challenges in education rather than the capabilities of technologies. Most importantly, they note that research focused on change cannot be done at a distance, and that change must be understood within the context of each school community.

Evaluating Technology

Variables. The unique influences of technology upon teaching and learning suggest that diverse variables for study are needed. The U.S. Department of Education has developed a useful guide for educators faced with evaluating technology in their schools. *An Educator's Guide to Evaluating the Use of Technology in Schools and Classrooms* is available online (www.ed.gov/pubs/EdTechGuide/).

One important variable to consider is the stage of implementation of the technology initiative. Schools often go through stages of technology implementation that may limit the scope of effects to be found. Schools need time to purchase and install hardware and software, train teachers on technology-related skills, and help them integrate technology into the curriculum. Effects may not be apparent in six months or a year; evaluations over several years might better demonstrate impact (Candiotti & Clarke, 1998; Heinecke et al., 1999). Evaluation designs should be longitudinal and account for these stages.

Several researchers suggest observable variables such as changes in disciplinary referrals, homework assignment completion, college attendance rates, and increases in job offers (Heinecke et al., 1999). Similar variables related to networked technologies include the number and roles of people who become involved in the school system and changes in times and places of instructional activities (Kozma & Quellmaiz, 1995). Other variables may be less tangible.

Ellett (1998) suggests a shift in focus from test scores to the active process of student learning. This process involves interactions among students, and between students and teachers. Learning is a social process and, as such, requires looking at technology use in this context. Technology use can be influenced by the variables of classroom organization, the sociocultural setting of the school, and pedagogical methods employed by teachers (Honey, Culp & Carrigg, 1999).

Sophisticated measures must be located or developed to evaluate such outcomes as changes in higher-order thinking, communication, research, and social skills. Additional outcomes may include perceptions from teachers and students about the implementation and quality of a program as well as effects of the program on community and family participation (Heinecke et al., 1999).

Kozma and Quellmaiz (1995) suggest that new distributed and distance-based educational settings will require teachers and students to demonstrate new skills and competencies that may be measured and studied. Due to the growing amount of information available, teachers may be assessed in terms of how well they help students find and evaluate this information and their facility with integrating technology into their teaching. Teachers must also be able to develop, monitor, and assess collaborative efforts among their students, as well as collaborate with colleagues. Student outcomes in network-based projects include in-depth knowledge of subject matter, demonstration of higher-order thinking skills, progress in self-monitoring strategies, and collaborative skills.

Strategies. Developing new assessment measures is a daunting task for school leaders already faced with many commitments. Evaluation models exist that may be applied or adapted in most schools. Wiggins (1997) describes his vision of a school in which assessment is indistinguishable from the teaching and learning process. Common activities such as note taking and dialogues between teachers and students become opportunities for assessment, as do such alternate assessments as digital portfolios (Penta, 1998) and simulations. Knowledge about these alternate forms of assessment can help develop a truer picture of the impact of technology in a school.

Honey, Culp, and Carrigg (1999) suggest that technology should not be viewed as a solution in isolation but rather as an integral part of curricular initiatives. Research with this systemic focus should be process-oriented and focused on change rather than just doing better within an older framework. Teachers must be partners in the process and must be able to exhibit a sense of ownership in both the innovation and the research process.

Kozma and Quellmaiz (1995) describe *cluster evaluation* as a method to help researchers assess diverse network-based programs. Cluster evaluation groups projects with similar features in an effort to economize the use of instruments and measures. Significant characteristics that can be used to cluster projects are primary goals, major educational approaches, audience, contexts of use, technology used, and resources with which the project was developed.

Several other projects describe strategies to evaluate innovative technology programs. These include feedback in the form of daily class surveys or small group sessions (Shaeffer & Farr, 1993), a technology-based classroom observation instrument (Gearhart, Herman, Baker, Novak & Whittaker, 1990), and an instrument designed to measure pedagogical activities compared to available technology resources (Moersch, 1996-97).

Using technology for assessment. Technology itself can create, store, analyze, and support assessment. Bahr and Bahr (1997) present a long list of procedures and equipment that can facilitate educational assessment. These technologies can be used for student assessment and they also create artifacts that in turn represent measures of impact. Procedures include

- assessment for instructional planning, in which the level of achievement students perform supports the planning of instruction and the development of interventions;
- dynamic assessment, in which a student's potential for learning is determined;
- progress monitoring, which addresses the rate of student learning as well as level of student achievement;
- curriculum-based measurement, in which a group of procedures assesses basic skills by using the student's actual curriculum for the development of items; and
- electronic portfolios.

Hardware and software that can be used for assessment include videoconferencing equipment, which can help with conducting screening interviews; computer-based scoring, which not only accelerates the scoring process but reduces errors often associated with hand-scoring; expert diagnostic systems; and test development software (Bahr & Bahr, 1997).

Sophisticated applications that adapt to user responses can reflect not only current goals and achievement but also data from past performances, which may be used as benchmarks for comparison. Student achievement can be compared against performance standards and benchmarks rather than the performance of others. Databases that track artifacts of student contact and achievement provide a trail of data to help school leaders make informed decisions not only about individual students but about global variables related to school programs as a whole (Wiggins, 1997).

Realizing the potential. Kozma and Quellmaiz (1995) perhaps best describe the potential for networked technologies. These technologies automatically gather and store data. They can be used to analyze this data by monitoring access, types of use, and user reactions, both to assess final impact and support formative changes in the program's design to better achieve desired goals.

Interactions between staff, professional development activities, and elements of the curriculum all leave artifacts on a digital network. Interactions can be analyzed by the number of participants, frequency of interactions, composition of groups, and focus of discussion. Curriculum can be judged for quality, alignment with standards, and compared to student achievement data. Teachers can further benefit from networked technologies by utilizing templates for notebooks, journals, and lesson plans—all of which can be captured in a standard form for ease of analysis by evaluators. Students, too, will leave artifacts on a digital network for possible analysis. Data can include frequency data on which resources students access and how often they are accessed. Logs of how students interact with each other, their teachers, and outside experts can be stored, and analyses of these interactions may provide insights into the depth of student reasoning, understanding of course content, and how well students collaborate with others (Kozma & Quellmaiz, 1995).

The assessment puzzle is a convoluted one. As schools become better versed in the capabilities and practices supported by educational technologies, the technologies themselves can support school leaders as they evaluate the impact of technology, make better-informed decisions, and communicate this impact to stakeholders.

Ethical and Legal Issues

Technology is weaving its way into all aspects of schooling. We use it to collect, store, and access student records. Teachers, students, and their families share information via Web pages, listservs, and e-mail. Students and teachers use and create digital and Web-based resources. Schools have long dealt with a variety of ethical and legal issues concerning teaching and learning, but the reliance on information technologies presents some new concerns for educators. The ease with which data can be created and shared also poses problems. It is not only easier to obtain and reuse materials found on the Internet or in digital resources; it is also easier to misuse them and to find inappropriate or even harmful material.

World Wide Worries

A recent survey (NPR, 2000a) indicated that many Americans have concerns over use of the Internet. Eighty-five percent of respondents worry about the possibility of dangerous strangers contacting children, and 84 percent have concerns about the availability of pornography on the Internet. This last fear may be justified, as the survey reports that 24 percent of children between the ages of 10 and 17 say they have seen a pornographic Web site.

These are not the only ethical and legal issues facing educators in a digital age, however. Educators must be mindful of security and privacy to prevent unauthorized individuals from obtaining student data (Olivia, 1999; Owens & Cohen, 1998). Administrators and teachers must be aware of how students are using the school's technology and must monitor what students publish (Burke, 2000). Schools must also respond to policies and legislation that dictate requirements to maintain accreditation (Anderson, 1996); provide access to all students by following requirements of the Americans with Disabilities Act (Consortium for School Networking, 1999); and uphold copyright and intellectual property rights of content creators, which are outlined in the Copyright Act of 1976 and the Digital Millennium Copyright Act of 1998.

Fortunately, the technologies that make it hard to create policy also provide easy access to information about legislation. Governments themselves, as well as watch-dog groups, often post proposed legislation, revisions, and final versions on the Internet. Some legislatures also broadcast committee hearings over television and the Internet. Two helpful Web sites for tracking legislation include the Consortium for

School Networking (www.cosn.org) and Thomas, Legislative Information on the Internet (thomas.loc.gov) sponsored by the Library of Congress.

The following provides an overview of a few key issues, such as acceptable use of digital materials, copyright and fair use issues, as well as concerns for distance education. Legal requirements for schools shift often and are impacted by local and state policy. Consult with district and state technology leaders to stay current with policy and regulations.

What Is Security?

School records such as grades, attendance, discipline, lesson plans, and professional development records can all be generated, stored, and accessed through a variety of digital tools. Gradebook programs were tools that many teachers used as their first steps toward integrating computers into their practice. Later generations of these tools can be shared over a network and can combine other common management activities, such as designing lesson plans, reporting attendance records, aligning curriculum activities with required content standards, and incorporating data from large-scale student assessments.

The ease with which records may be created, stored, and distributed makes security a pressing concern for schools as they incorporate digital record keeping and communications. Student information is confidential and must be secure regardless of the format. The issue of security presents greater challenges when an electronic network includes student data and also supports communication between the school and—literally—the rest of the world.

Ranalli (2000) notes that security is a general term and it may imply that there is a general solution, such as a checklist or piece of software, that can be applied to solve the problem. Instead, he suggests that security should be a deliberately cultivated mindset, one that requires a continual awareness of any issues that may compromise the integrity of a system.

Security is complex and difficult to achieve. The large number of people associated with most systems creates a large number of opportunities for the system to fail. Security holes and breaches are hard to detect and, once detected, it is almost impossible to find out how they occurred. The most common failure points are

- administration errors that occur when adding and removing users from the system
- bugs in the system
- configuration errors
- lack of auditing the system
- lack of adequate resources spent to develop and maintain the system

Tracking Legislation

Children's Internet Protection Act. The success of the E-Rate program, also referred to as universal service, has helped to connect most of the nation's schools to the Internet. Recent legislation impacts this support, which is offered as discounted rates for Internet connectivity. The Children's Internet Protection Act (CIPA) amends the earlier Communications Act of 1934 and will require schools and libraries receiving E-Rate funds to incorporate technology-based solutions to block access to material defined as obscene, pornographic, or harmful to minors (Consortium for School Networking, 2001). The act is sometimes called the "Filtering Mandate."

Initially, this act requires schools and libraries that receive funding under the fourth round of E-Rate allocations to certify to the Federal Communications Commission that they have complied with CIPA by installing a technology-based solution to block material as outlined in the act. The first certification deadline was October 28, 2001. Educators should follow the actions of the Federal Communications Commission, the U.S. Department of Education, and the Institute for Museum and Library Services for interpretive guidance for entities that have received E-Rate allocations during the first three rounds or that renew their E-Rate funding allocations.

Children's Online Privacy Protection Act. Use of the Internet by children is a divisive issue. While many parents and schools would like to allow children to access the wealth of material mounted by reputable services and institutions, there is a concern for the safety of individuals using Web sites. Web users can be anonymous and children must be careful about the information they divulge on Web pages and in discussion areas, such as chat rooms.

The Children's Online Privacy Protection Act (COPPA) was passed to help safeguard children as they use the Web (Center for Media Education, 2001). Central to this legislation is the information that may be collected from children as they use the Internet. Web sites that target children under age 13 must follow guidelines regarding the collecting of personal information. These Web sites must limit the detail of information they collect from children and must post notice about the information they collect and how that information is used.

Electronic Communications Privacy Act. The Electronic Communications Privacy Act addresses security and confidentiality issues of electronically disseminated communications (Legal Information Institute, 2001). Many schools provide guidance to students, staff, and parents through an Acceptable Use Policy. These AUPs may be part of school handbooks or policy manuals and many include "hold harmless" language for abuses of the school's technology. The Acceptable Use Policy is signed by students and parents and kept on file. Some schools take a further step and notify all parents annually of the school district's policy on using educational technology and the risks this may entail. This way, students who fail to sign an Acceptable Use Policy may have access to these important tools.

E-mail should never be considered private or confidential. Messages can inadvertently—and sometimes intentionally—be intercepted. Schools or districts that provide e-mail services must emphasize this point with everyone who uses the system, including students, parents, and staff members. Some schools only provide e-mail for teachers or activity-based e-mail class accounts for a limited duration, such as a grading period or the length of a school-based project. Schools that use outside service providers should carefully negotiate the extent to which school officials will be able to review and distribute e-mail messages.

Family Educational Rights and Privacy Act. As districts and entire states move to large-scale networked services for record keeping, building administrators may become less involved with selecting the hardware and software that will keep these records secure. However, issues concerning student data will arise and must be handled at every level, including how teachers and staff access information from their classrooms or office.

Schools that utilize electronic media for record keeping must still follow guidelines for the storage and disclosure of student information set forth by the Family Educational Rights and Privacy Act (Family Compliance Office, 2001). Schools must notify parents annually that records can be reviewed and must be able to comply with this request within 45 days. Network-based data management records should support these requests. Also, schools are still required to obtain written permission from a parent or legal guardian to release student records. There are some records, usually those that fall under the label of "directory" information, that can be distributed under some conditions—even on a Web page.

Faculty and staff should fully understand policies concerning access to student data and must take great care in accessing and retrieving data. Schools should consider the levels of access that will be provided to faculty and staff members and should enforce policies for sharing this data.

Copyright legislation. Copyright law is complex and changes with each session of Congress. The current law is the Copyright Act of 1976 with amendments and is available online at www.loc.gov/copyright/title17/. Recent legislation such as the Digital Millennium Copyright Act of 1998 begins to address the complications of digital material. Copyright legislation will continue to evolve in an attempt to keep abreast of technological changes. Consult district and state legal services on specific questions and visit the Web site for the U.S. Copyright Office at the

Library of Congress for more information (lcweb.loc.gov/copyright).

Copyright grants the holder the five rights:

- to reproduce the copyrighted work in copies or phonorecords;
- to prepare derivative works based upon the copyrighted work;
- to distribute copies or phonorecords of the copyrighted work to the public by sale or other transfer of ownership, or by rental, lease, or lending;
- in the case of literary, musical, dramatic, and choreographic works, pantomimes, and motion pictures and other audiovisual works, to perform the copyrighted work publicly;
- in the case of literary, musical, dramatic, and choreographic works, pantomimes, and pictorial, graphic, or sculptural works, including the individual images of a motion picture or other audiovisual work, to display the copyrighted work publicly (Copyright Law of 1976).

Material does not have to be registered or display a copyright statement, but it must be original and be in a fixed, tangible medium. E-mail, listserv messages, threaded discussions, and Web pages meet these two important criteria and they should be considered copyrighted material (Baird & Hallett, 1999; Rothman, 1995). Warn teachers and students against the illegal practice of copying and using digital material without permission from the copyright holder, whether this material is text, pictures, graphics, or other multimedia elements.

Software is copyrighted and is usually licensed. Pay strict attention to licensing agreements for software. Use cloning software on a lab or network server to periodically check the network for appropriate software and remove non-licensed software (AEL, 2000). Many digital materials are now protected by technological protective measures (TPMs), and the DMCA assigns stiff penalties to anyone found guilty of bypassing TPMs to obtain copyrighted material (Lutzker, 1999).

Fair use. Fair use guidelines establish criteria for the use of copyrighted materials in educational settings (Harper, 2000). Many educators falsely assume that copyrighted material may be used for instruction with little or no restriction. Copyright infringement may still occur even if a work does not display copyright notice or if only a small portion of the material is used (Salomon, 1999). The following four criteria have evolved to help the courts determine whether material falls within fair use:

- the purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes;
- the nature of the copyrighted work;
- the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and

- the effect of the use upon the potential market for or value of the copyrighted work (U.S. Copyright Office, n.d., p. 6).

Educators may incorporate multimedia for classroom instruction or projects under the Fair Use Guidelines for Nonprint Works if the portion used does not exceed 10 percent of the original copyrighted work. It can be used for up to two years and no more than three copies can be made; two for class use and one for preservation (Baird & Hallet, 1999).

Distance learning and intellectual property. The growth of distributed and distance-based learning courses has further complicated the issues of fair use and intellectual property. While distance-based courses may cover curricula identical to traditional face-to-face counterparts, copyright restrictions are more stringent for distributed delivery.

Distance educators should not only seek rights to use materials in a course but to transmit materials over a network. Works that may be transmitted over a network are limited to nondramatic literary or musical works, which exclude motion pictures, videos, or any audiovisual format. This means that while a videotape may be shown in a face-to-face classroom, a distance-based instructor must have permission to transmit the same videotape over a network every time the videotape is shown (Baird & Hallett, 1999).

Many educators think the current laws are too restrictive and call for expanding the fair use policies enjoyed by face-to-face instructors to include distributed and distance-based learning environments. Lutzker (1999) points out the more stringent policies for distance learning, such as the near impossible tasks of identifying copyright holders on items such as photographs and obtaining clearances for spontaneous use of copyrighted works. Licensing copyrighted materials for each access in distributed and distance-based learning courses can be prohibitively time-consuming and expensive.

Distance-based learning environments have forced many instructors to assume the role of course developer. Ownership of the course itself and of digital course materials—such as Web pages, graphics, and Java applets—is hotly debated. In the world of higher education, a scholarly work created on condition of employment, such as lecture notes or a course syllabus, is owned by the employing institution, but most institutions will confer ownership to the faculty member. Patents created by faculty, staff, and students traditionally remain the property of the institution. Policies differ, but many institutions are opting to treat digital material created for distributed and distance-based courses as they do patents and are retaining ownership (Salomon, 1999). As more opportunities for distributed and distance-based learning develop in the K-12 setting, school districts will face the same copyright and intellectual property issues.

Using the Internet

Many proponents of Internet use in the classroom view the seemingly unlimited amount of information and the ease of communicating with people all over the world as benefits. These same characteristics may dissuade some educators from including Internet-based instruction due to the possibility of contact between students and undesirable Web sites or individuals. Make decisions about Internet use based on district experiences and policies with existing instructional tools and on research about strategies and tools that increase the Internet's potential to support teaching and learning.

Internet use decisions must reflect local policy and community needs, but completely ignoring the Internet inhibits the school's ability to prepare students to work and live in a knowledge age. Many schools have harnessed the Internet to support instruction and help their students practice acceptable and responsible use; any school can do the same. A variety of strategies, policies, and tools can support responsible Internet use. The most popular include teaching and monitoring strategies, Acceptable Use Policies (AUPs), and filtering software (Burke, 2000; Mason, 1997; Pownell & Bailey, 1999).

Responsibilities of online service providers. Schools and libraries often serve as Community Access Centers and even Online Service Providers (OSPs). Districts that serve as OSPs must be aware of the Digital Millennium Copyright Act (DMCA) (Lutzker, 1999; Samuelson, 1999). The DMCA considers educational institutions that offer Internet service to students, staff, and faculty to be OSPs, much like America Online (AOL) and other major service providers (Salomon, 1999).

The DMCA outlines compliance practices and actions that must occur when users of the system participate in activities that infringe on the rights of copyright holders. The DMCA provides exemptions for OSPs if they act in accordance with the law, such as terminating service to repeat offenders and removing material from the system upon receiving notice of copyright infringement (Digital Millennium Copyright Act, 1998). The DMCA is available online at lcweb.loc.gov/copyright/legislation/hr2281.pdf.

Strategies to educate and inform. Educators and parents should help students develop responsible and appropriate Internet use habits. Burke (2000) provides several methods teachers can use to supervise student use of the Internet. Place computers where they are easily visible by teachers, librarians, or aides. Limit online time to encourage students to stick closely to learning goals. Group students at the computer to discourage inappropriate use. Teachers must also help students learn how to validate the accuracy and evaluate the usefulness of Internet sources.

Before beginning an Internet-based project, teachers should demonstrate successful search strategies and review responsible use practices. Students should be familiar with citation strategies for both digital and print materials to avoid plagiarism and copyright infringement. Students should know the consequences of illegal use of digital materials (Burke, 2000).

Additional tips for responsible, proactive use of the Internet include:

- Be sure the curriculum objectives and goals for Internet use are clearly delineated.
- Get to know students' online haunts and 'friends.'
- Never allow unsupervised surfing of the Internet.
- Teach students Internet safety.
- Teach youngsters that there are laws against harassment, and if they feel seriously threatened, they should report this to an adult immediately (Truett, Scherlen, Tashner & Lowe, 1997, p. 52-53).

Acceptable Use Policies. An acceptable use policy (AUP) is a set of guidelines governing use of the Internet for school activities (Anderson, 1996; Rockman, 1998; Truett et al., 1997). AUPs are often district initiatives and may require students and their parents or guardians to sign letters of agreement. Internet AUPs vary greatly, but most districts agree the primary purpose of the policy is to support research and instruction. Most policies stem from existing policies regarding codes of behavior and use of traditional resources, such as books, magazines, television, and radio (AEL, 2000).

The following list provides a variety of acceptable uses that may be addressed in an AUP:

- being polite and using appropriate language
- enforcing appropriate use and reporting misuse or security issues
- using the Internet ethically and legally
- respecting copyright and license agreements and citing material
- deleting unwanted messages or old data from computers
- using online time efficiently
- running virus software on downloaded files or inserted disks
- acknowledging the receipt of documents or files
- signing correspondence
- abiding by the policies and procedures of other networks that are accessed (AEL, 2000)

The following list provides a variety of unacceptable uses that may be addressed in an AUP:

- giving out private information, such as addresses, phone numbers, or passwords

- assuming the identity or using the passwords or material of another
- transmitting material that violates any U.S. or state regulation, such as copyrighted, threatening, or obscene material, or material protected by trade secret
- downloading text, graphics, or software, or engaging in behavior that may be considered obscene, abusive, libelous, indecent, vulgar, profane, or lewd
- altering software by deleting files, downloading programs, or copying or installing commercial programs
- plagiarizing someone else's work
- harassing an individual using the Internet
- vandalizing equipment or electronic material
- conducting commercial activities
- advertising products or services
- taking part in political lobbying
- disrupting the Internet use of others
- spreading computer viruses willfully
- gaining access to any pay-for-view site (AEL, 2000)

Technology to support acceptable Internet use. A variety of tools support acceptable Internet use. These include using approved digital resources and services, providing access to materials on an intranet or through a proxy server, and several filtering-type software applications. Of these, filtering software promotes the most heated discussion. Opponents may feel that filtering software is a form of censorship, while proponents may feel that it allows students to safely search the Internet, avoiding contact with undesirable Web sites or individuals.

Teacher concerns about the potential for inappropriate use has greatly reduced classroom use of the Internet in many instances (Schofield & Davidson, 1997). However, officials in Tennessee note that Internet use has increased since filtering software was installed on the statewide network, ConnecTEN, in November 1998 (Burke, 2000).

People who believe that information can change the way a person thinks and believes often support the use of filtering software (Pownell & Bailey, 1999). The increasing amount of information available on the Internet and the unlimited topics it covers also lead proponents to encourage the use of filtering software. The growth rate of information is so quick that filtering software offers one solution to providing a supportive environment for teaching and learning. Filtering software is also less expensive than evaluating or previewing individual sites (Bruce, D., 1999).

Unfortunately, filtering software is not always effective (Pownell & Bailey, 1999). The rapid growth that may encourage filtering software use also limits its effectiveness. Filters can block desirable sites and they must be updated often to keep pace with the growth of material on the Internet. Filtering software does not take into account the varying ages, levels of maturity, and individual needs of users. Keywords used to ban sites are often derived subjectively and most filtering services do not publish their lists (Bruce, D., 1999). Schools that use filtering software without knowing what sites are being blocked and why may unintentionally censor materials that are constitutionally protected. Schools or filtering software developers that claim they prevent students from viewing objectionable material may also open themselves up to litigation if the software is not completely effective (Pownell & Bailey, 1999).

No one strategy can solve all unacceptable use problems and no one should rely solely on a technological tool. Training for parents, teachers, and students will help reduce the number and severity of problems one might encounter (Burke, 2000).

Conclusion

The research cited here demonstrates technology's far-reaching impact on all facets of education. The resulting changes have increased pressure on school leaders, both to integrate new technologies into their own work and to assume new roles for which they may be unprepared. For technology to have a positive impact on student achievement, school leaders must envision, direct, and support the successful integration of technology into teaching, learning, and school management. This requires them to observe and evaluate emerging trends in technology and select promising strategies and tools. They must be able to successfully assess the instructional needs of their schools and negotiate technology solutions that support their goals and objectives. They must also deal with the human side of the equation by providing appropriate training and support. Ethical and legal concerns shift constantly, and school leaders must actively monitor these changes. Fortunately, many innovative practitioners have led the way toward the successful integration of technology and offer many lessons for those who follow, and follow they must as technology continues to change the way we live, learn, and work.

Summary of Key Findings

Vision

- Necessary literacy skills include abilities to search and sort, analyze, evaluate, and synthesize information relevant to a particular task or need. This information must then be applied to generate new data, information, or products.
- Technology can help students develop basic information skills by simulating today's work with real-life examples and reality-based experiences, and by motivating them to learn.
- New skills do not supplant efforts to set or raise current academic standards. Skills necessary for becoming or remaining literate change as society changes.
- School leaders must be able to create and communicate a vision that synthesizes the needs of diverse groups while fostering contin-

ued excellence in teaching and learning within local schools and districts.

- Mirroring the requirements of the new workforce, new roles for teachers de-emphasize the presentation of facts and instead ask teachers to help children learn how to think critically, solve problems, and make informed decisions.
- In institutions that have embraced technology, studies show that the teacher's importance has not lessened but that systematic use of technology actually upgrades and enhances the teacher's role.
- Technology is more effectively integrated in schools when school leaders are informed about and comfortable using technology.

Planning

- Technology planning should become an integral part of annual budgeting, training, data gathering, and assessment of school performance.
- A technology plan should span more than one year and have enough flexibility to accommodate new and emerging technologies, teaching strategies, and data from evaluations.
- Including community and business leaders in planning offers many benefits, for these partners may leverage financial support, become powerful advocates for school projects, and communicate with the community at large.
- The technology plan should address the costs of purchasing equipment and software; developing a network infrastructure; constructing and/or retrofitting facilities; professional development, materials, and substitute teachers; equipment maintenance and technical support; and replacement of old, broken, or obsolete equipment and software.
- A well-crafted technology plan should use information gathered during the needs assessment phase to outline expected returns and describe alternative indicators of success.
- A strong technology plan addresses how matching money will be sought and how the finances will be managed.
- Software decisions should be made only after reviewing curricular goals and matching software appropriately. Software selection should drive hardware choice.
- The evaluation plan should be oriented to the goals and objectives developed in the planning process and should provide means to determine whether and how well these goals and objectives are being met. Evaluations should be planned from the very beginning and take place periodically throughout.

Community Relationships

- Established partnerships can support long-term technology initiatives by developing ways to sustain these efforts after initial funding has been spent.
- Communication is necessary for the success of any technology program, and establishing strong external relationships can facilitate communication.
- An effective means of convincing the community at large of the effectiveness of technology-based programs is to involve them in their children's education.
- Information technologies can support greater school-to-home and school-to-community connections.

Tools and Media

- Productivity tools are best suited to replicate seat-based work and complete traditional student activities, namely research papers and reports. Word processing applications are the most familiar productivity tools; others include spreadsheet and database applications. Productivity tools and drill-and-practice software—similar to traditional flashcards—are the most commonly used applications in the earliest stages of software integration.
- Benefits of developmental software include increasing users' intelligence, verbal and nonverbal skills, long-term memory, manual dexterity, and problem-solving and conceptual skills.
- Software type is a factor when considering the effectiveness of computers as learning tools.
- Technology use reflects technology experience.
- Software selection becomes an increasingly important skill for teachers to learn. Teachers should know their system requirements, instructional goals, and software expectations to make informed decisions.
- Schools have invested in hardware, but the software that provides functionality to these materials has not been purchased.
- Linking software use to student achievement demands effective technology integration, which, in turn, requires highly confident teachers who are skilled in effective pedagogy, hardware and software use and support, classroom management, and content knowledge.

Integration

- Integration can include learning about technology; students should do this in meaningful ways. Software should enable students to use computers flexibly, purposefully, and creatively.

- Learner needs include explicit information, recognition of achievement, flexible access to resources and support, opportunities to practice skills and apply knowledge, and feedback on performance.
- Effective technology-enhanced pedagogical strategies can result in at least four kinds of improvements in education outcomes: increased learner motivation, mastery of advanced topics, students acting as experts do, and better results on standardized tests.
- Technology integration often results in teachers rethinking their underlying beliefs about teaching. These changes could manifest themselves outwardly in the form of new teaching strategies, activities, and forms of assessment, but this may take some time.
- Success of technology is strongly related to teacher enthusiasm, initiative, and sense of improvement. Teacher interest in technology is highest when they have access to enough hardware, use applications they care about, and receive relevant training.
- Teachers progress through five stages as they effectively integrate technology into their daily practice: entry, adoption, adaptation, appropriation, and invention.
- Teachers should be given the time to learn and the time to practice using their new skills.
- There are several elements of particular importance to undertaking an innovation, including innovations in technology integration:
    - ✦ Individual focus: Without the growth of individuals no innovation will succeed.
    - ✦ Developmental stages: Successful progression through the innovation arrives at a stage in which participants have thoroughly incorporated the innovation so that synthesis of ideas, methods, and materials becomes the starting point for a new generation of innovation.
    - ✦ Ownership: Without buy-in from the participants, the innovation will not be implemented as desired.
    - ✦ Focus for evaluation: Evaluation must first consider the stage of adoption of individual participants and the innovation as a whole.
- A well-developed integration plan outlines concrete, time-based goals and strategies for achieving these goals, including funding, training, and benchmarks for ascertaining whether goals are achieved.
- The most technologically advanced teachers are often recruited by industry.

Professional Development

- One of the most crucial elements for increasing the return of investment on technology expenditures is professional development.
- Failing to implement an effective, ongoing professional development initiative will severely limit a school's or district's ability to achieve its technology goals.
- Teachers need time to build skills, become familiar with software and content, and to practice integrating technology into their content presentation and learning activities. They also need incentives and ongoing support.
- Teachers need the opportunity to discuss technology with their peers and may benefit from ongoing mentoring and consultative support.

Access

- To optimize return on technology investments, school districts should make sure all students and teachers have easy, reliable access to technology that supports learning goals.
- Common barriers to technology access include geography, economic status, individual learning styles, and special needs.
- Indicators of access include connectivity, ubiquity, interconnectivity, and equitable use.
- All but five percent of the nation's schools are connected to the Internet, and the percentage of classrooms connected to the Internet has risen substantially.
- Information technology can empower dispossessed groups to achieve their goals.

Support

- Lack of support presents many barriers to adopting emerging technologies into education. These may include the scarcity of technical support and adequate staff to maintain the technology infrastructure.
- To be successful, school leaders should provide pedagogical support to teachers faced with integrating technology into their classrooms.
- Support and professional development are often the largest ongoing costs and are considered the most critical components in the effective integration of technology, but often receive less attention than hardware, software, and network connectivity.
- Estimates say that the typical teacher will take three to six years to fully integrate educational technology into teaching and learning;

ongoing changes and advances in technology may mean this process is never fully complete.

- The number of support staff needed may depend on the actual number of workstations, as well as the variety of platforms, operating systems, and software applications.
- When a designated support person cannot be hired, many districts rely on teachers with technology experience.
- Robust online environments can support professional development opportunities in basic maintenance and troubleshooting skills as well as advanced pedagogical strategies—often with flexible scheduling and in the convenience of teachers' homes.

Accountability

- Traditional forms of assessment often fall short when evaluating the impact of educational technologies.
- Drill-and-practice and computer-assisted instruction (CAI) have demonstrated positive gains in student achievement, and there is evidence that a variety of specific applications lead to improvements in student performance, student motivation, and teacher satisfaction.
- Increased access to technology positively impacts student achievement.
- Grades and test scores are not the only measures of success. Improvement can take many forms and may include the performance of teachers, administrators, and other staff; delivery of programs and services to students, parents, and the community; and ability of the school community to accomplish its mission.
- Multimedia use often results in increased student interest and greater student attention.
- Observing their teachers facing and overcoming technical difficulties, students learn lessons about problem solving and decision making and also that setbacks in technology are common.
- The impact of technology on teaching and learning should be understood in context.
- Evaluation designs should be longitudinal and account for stages of implementation.
- Networked technologies automatically gather and store data; thus, they can be used to analyze this data by monitoring access, types of use, and user reactions, both to assess final impact and support formative changes in the program's design to better achieve desired goals.

Ethical and Legal Issues

- A majority of people expressed concerns about the dangers of the Internet.
- The ease with which records may be created, stored, and distributed makes security a pressing concern for schools as they incorporate digital record keeping and communications.
- Fair use guidelines establish criteria for the use of copyrighted materials in educational settings. Many educators falsely assume that copyrighted material may be used for instruction with little or no restriction.
- Distance educators should not only seek rights to use materials in a course but to transmit materials over a network.
- Strategies, policies, and tools that support responsible Internet use include teaching and monitoring strategies, Acceptable Use Policies (AUPs), and filtering software.

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