Connecting Classrooms, Computers, & Communities

U.S. Department of Education

Connecting Classrooms, Computers, & Communities:

A National Plan for Technology in Education

United States Department of Education

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Preface

As the 1990s dawned, interest in the potential benefits of harnessing powerful new technologies to the improvement of teaching and learning became intense, widespread, and bipartisan. Recognizing this situation's potential, Congress, in P.L. 103-382, *The Improving America's Schools Act of 1994*, called on the Department of Education to prepare a plan to promote the use of technology in education.

Early in its tenure, the Clinton Administration announced that promoting the use of technology to support learning and developing a national information infrastructure (NII) would be major priorities.[1] *Technology for Economic Growth, A New Direction to Build Economic Strength*, the Clinton Administration's blueprint for technology policy, called for improved technologies for teaching and learning, the introduction of telecommunications equipment and computer software into classrooms, improvements in the productivity of learning, and the extension of learning into community, home, and work settings.

In 1995, Speaker Gingrich of the U.S. House of Representatives pointed to telecommunications and "cyberspace" as new American frontiers and speculated about the desirability of providing every low-income, inner-city student with his or her own lap-top computer. In the same year, *Common Ground*, the report of the National Information Infrastructure Advisory Council, recommended that by the year 2000 all

[1] Appendix B provides a glossary of technical terms.

community-based institutions serving the public (including schools and libraries) be connected to the NII.

Finally, both Secretary of Education Richard W. Riley and Deputy Secretary Madeleine M. Kunin have been committed to ensuring that America's classrooms obtain practical, useful technologies so that teachers can teach better and students can learn more effectively.

For the past year, a Department of Education team has worked to develop the plan presented in this document.[2] The team convened a national conference and seven regional forums on educational technology to hear the views of teachers, administrators, and parents. It organized interactive on-line forums with parents, students, teachers, administrators, and experts on new and emerging technologies. It met frequently with its counterparts in other federal agencies and with the National Information Infrastructure Advisory Council. It solicited the assistance of the RAND Corporation in developing the framework for this plan and sought out the best thinking of experts in the field through workshops and several commissioned papers.[3]

This document outlines the results of that work. It is an action plan for educational technology in the United States. It proposes to infuse the very latest and best technologies into the nation's classrooms, and more than that, it sets forth a blueprint to provide students and teachers with the computers and technologies they need to face the challenges the 21st century will place before them.

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[2] For a list of activities, meetings, papers, and products involved in developing the plan, see Appendix A.
[3] Copies of all supporting documents are available on-line at http://www.ed.gov

CONNECTING CLASSROOMS, COMPUTERS, & COMMUNITIES

by

Richard W. Riley
Secretary

Some years ago, a business leader reminded me that the adventurers who set out for the New World were able to smell land long before they caught sight of it. Like those mariners, said this businessman, today's leaders have to be able to "smell the future." They have to be able to think long term and see beyond the horizon.

I believe the future beckons America. It promises rewarding jobs. It offers to diminish the drudgery and toil of daily labor. It opens prospects of abundance and rising standards of living for every American.

All of these things are possible if our children are prepared -- if they are provided with the tools they need to adjust to new circumstances and changing times. The wealth built by our forebears from coal, steel, oil, concrete, and brawn can be built tomorrow from silicon chips, integrated circuits, digital networks, computers, and raw intelligence.

In a larger sense, all of these things are possible because Americans have always understood that the future is not something that simply arrives, but something that is created by the actions we take today to secure our children's tomorrow.

Throughout history, the march of human progress has been marked by milestones in science and technology. Gutenberg's creation of moveable type in the 15th century laid the foundation for universal literacy. Watts' invention of the steam engine in the

18th century launched the Industrial Revolution. The inventiveness of Bell and Marconi in the 19th and 20th centuries -- creating the telephone and radio -- helped bring a global village into being.

The United States and the world are now in the midst of an economic and social revolution every bit as sweeping as any that has gone before, one grounded in telecommunications and digital technologies. When this year's infants enter school in the year 2000 -- and this year's eighth graders graduate -- these technologies, and the national and international infrastructures they make possible, will be commonplace. These children must be prepared to make their way in this new age, in this different world.

Pull Quote 1

Entering this new environment, the United States will either lead the transformation or it will follow the lead of others. Hence the importance of this technology plan. If this generation of Americans has the courage to do for its children what prior generations did for theirs, the possibilities for the United States are limitless.

If this generation does not possess that courage -- if it falters, hesitates, and ultimately refuses to open the door to the digital era -- global competitors will certainly open the door first, and thereby reap the rewards.

And if this transformation is to come to full bloom, it must take root in the nation's schools, for it is in the nation's schools, with their 50 million students and 2.9 million teachers, that the country's future is conceived, created, and secured. And it is in the schools that the United States will obtain the greatest returns on its investments in technology -- immediate returns in the form of more productive and rewarding teaching and learning, and longer-term benefits of geometric increases in individual and national productivity.

EDUCATION AT A CROSSROADS

Education in America is at a critical crossroads.

On the one hand, in the past decade, parents, educators, legislators, and business and community leaders have worked hard to create a broad-based, bipartisan consensus on how to improve American education. The result of these efforts is the *Goals 2000: Educate America Act,* passed by Congress and signed into law by President Clinton in 1994. Goals 2000 lays out eight national education goals and helps establish top-down support for bottom-up reform.

On the other hand, the use of technology in American life has exploded in that same decade, affecting everything from the workplace to the living room. As Secretary of Education, I have come to believe that it will be possible to provide every student with the kind of quality education outlined in Goals 2000 only if our young people have access to these new technologies and information tools -- to computers, networks, CD-ROMs, modems, and the emerging national information infrastructure (NII), also called the information superhighway.

Pull Quote 6

The information superhighway is a "seamless" web of computers, communications networks, libraries, databases, and consumer electronics that will put vast amounts of information at our fingertips. Ultimately, it will tie together telephone systems which already reach 98 percent of households; cable systems that pass by more than 90 percent of homes; broadcast and radio stations; cellular telephone systems and other wireless networks; satellites already offering programming directly to owners of "dishes" no larger than a salad bowl; and enormous information data bases.

What can these tools do for American classrooms and their teachers and students? As this plan makes clear, technology can help tailor instruction to the individual needs of students; improve instructional management; support teachers and their professional development; connect student learning with the real world and schools to the home and community; and expand time for learning beyond the traditional school day.

Much of the body of this plan describes these in greater detail, and acknowledges, quite candidly, a set of challenges that the nation must meet if they are to become realities. But the main point is incontestable. When every engineer has finished exploring the last detail of how to wire schools, when educators have had the final word about how to improve teaching and learning, and when analysts have satisfied themselves with a vision of the prospects for tomorrow, a simple objective for the United States and its schools stands out:

We should set for ourselves the goal of providing a learning system that permits all of our people, young and old, to learn *whatever* they need to, *whenever* they want to, *wherever* they choose to.

The nation should set out to create the kinds of learning institutions it has always wanted and needed -- schools that tailor instruction to the specific, *individual* needs of each student and that encourage students to learn at their own pace and throughout their lives.

Pull Quote 4

FREE PUBLIC EDUCATION & ITS ECONOMIC VALUE

The principle of free public education for all children is the bedrock of our democracy -- not "cheap," not "half-priced," not "cut-rate," but in its very essence "free."

Educational institutions, large and small -- schools, libraries, literacy centers, early childhood centers, community colleges, and universities -- should have total access to and use of services on the information superhighway. There should be "on-ramps" and "off-ramps" to every classroom. If cost limitations or other practical considerations make it impossible to connect the NII with all educational institutions immediately then schools, libraries, and literacy centers should be at the front of the line when public institutions are linked in the decade ahead.

Why at the front of the line? In the coming decade, this nation will have approximately 55.9 million students in public and private schools -- five million more than we have today.[4] A growing proportion of these young people will be Latino and Hispanic, African American, or new immigrants, many of them low-income and traditionally under served by our schools.

Parents understand how important it is that their children learn, all the more so in a technological age. As technology breaks down the walls separating home from school, and as students and parents are connected with distant libraries and classrooms around the globe, community leaders must make sure that no child is left behind.

Pull Quote 3

SIDEBAR ON CHRISTOPHER COLUMBUS MIDDLE SCHOOL

Educators know how valuable technology is to students isolated by geography or challenged by poverty or disability. New satellite and distance learning techniques can bring the best teaching to the most remote home or school. Well-implemented instructional learning systems (ILSs) have produced some spectacular results for low-income children in compensatory (Title I) education programs. The same technologies

[4]National Center for Education Statistics, *Projection of Education Statistics to 2005*, p.9

used to train pilots are being used experimentally to teach children with cerebral palsy how to operate motorized wheelchairs and negotiate the obstacles they might find in a typical classroom or on a busy street.

It is no secret that a young person who receives a quality education becomes a more dependable worker, a better citizen, and a stronger consumer. If the nation continues to ignore the educational needs of students -- particularly low-income students -- and continues to give them a watered-down curriculum and link up their schools last, it will find itself in an economic bind of the first order: it will have a work force that does not know how to work.

Pull Quote 5

And if the United States continues to think short term, as in the 1980s, the results are potentially disastrous. Every year, large corporations and small businesses, two- and four-year colleges, and public and private universities spend billions of dollars on remedial education. If the nation does it right the first time, it can eliminate this costly and wasteful need to keep redoing it. To create a well-educated, world-class work force, now is the time to get it right -- and get it right the first time.

Recent disturbing reports suggest that low-income inner-city and rural neighborhoods may be the last ones served by new technologies. I am convinced that all children can learn more if they are properly challenged, but they cannot do so without access to these new educational tools. I believe that early investments in technology will provide handsome, long-term economic returns, and that the expenditures will be returned to all of us, many times over, in the form of lower public assistance expenditures and greater national productivity. Technology is not an expense, but an investment in our common future.

GETTING FROM HERE TO THERE: HOW TO PROCEED

How best to proceed with that investment is a challenging question. Conflicting views on the role of the federal government in education present a problem, the rapidity with which technology is evolving requires attention, and the central place of the private sector in technological evolution demands respect. Since a strategy *for the nation* cannot be imposed by the federal government, how do we get from here to there and how should we proceed?

Pull Quote 7

Nobody expects the federal government to solve all the problems associated with educational technology. But parents and educators are demanding leadership to see that problems and issues are addressed.

Government's role at all levels-federal, state, and local -- is to point people in the right direction and urge them along the road. Officials should use their "bully pulpit" to define the stakes involved in the educational technology debate and encourage public and private leaders to tackle the challenges ahead.

The first thing to understand is that technology is not a cost but an investment. Educators need an investment mentality that is firm, fair, and flexible.

Schools should firmly commit themselves to technology as the wave of the future. Nothing will more quickly defeat the effort to improve learning and technology than half-steps, half-measures, and half-hearted commitment. The strategy is doomed that concludes, "We will put an extra computer here, and purchase an extra piece of software there, and provide a little extra teacher training elsewhere -- as soon as we find a little extra money." As everyone knows, "a little extra money" is hard to find. Much more

likely to succeed is a firm strategy based on a clear vision of what is to be accomplished and how school leaders propose to get there.

Policy planning must also be fair. Whether schools invest in technology or not, children from affluent and middle-income families will enjoy access to the latest technologies in their homes -- including powerful personal computers and peripheral devices such as CD-ROMs, scanners, printers, modems, and network connections. State and local leaders should insist that schools in the lowest-income neighborhoods be the first, not the last, to be provided with the latest technologies, not the last.

Finally, although schools should be firm in their commitment to technology and fair in their allocation of it, they must also be flexible in their implementation. The useful lifetime of many of today's technologies is about five to six years. In fact, the power of integrated circuitry is expanding so rapidly that new, cutting-edge computer platforms and affiliated software appear about every 18 months. In the last decade, technology has matured so rapidly that many public schools -- like many governments, homes, and private sector firms--are already saddled with badly out-of-date equipment. In this context, schools need to be flexible enough to stay abreast of change, and not be so completely wedded to one way of doing things that they are unable to respond as these technologies mature.

THE FUTURE CONTINUES TO BECKON AMERICA

As the action plan which concludes this document makes clear, bringing the full fruits of new technologies to our schools depends on many things. Schools need expanded access to the information highway. They need better tools and educational software. They need independent analyses and trustworthy advice about the benefits of technology. And they need new alliances with the private sector. Above all, our nation needs to do a much better job with technology training--developing teachers' professional skills with these new tools.

Pull Quote 10

As Secretary of Education, I have become convinced that the Department of Education's leadership role in this entire area can best be met by tackling the teacher training and professional development issue head on. When all is said and done about access to the information highway, tools and software, research and development, and partnerships with the private sector, the essence of the plan described in this document can be summed up in one sentence: **By the year 2000 the nation will have provided every teacher in the United States with the opportunity to take advantage of first-class training on the latest and most up-to-date technologies available for the classroom.**

It is quite clear that technology offers profound new prospects not only for learners but also for teachers. Computers and telecommunications can improve the professional working lives of teachers. They can help generate and modify instructional materials. They offer ongoing interaction with a wide circle of peers, instantaneous communication with instructional and subject-matter experts, and access to enormous quantities of background and reference materials. They can, in brief, help redefine the teacher's role.

In one sense, the nation owes its teachers nothing less. In another, it owes its students nothing less. But in the final analysis, the nation owes itself and its future nothing less. It is time, once again, for Americans to "smell the future." That future, and all of its promises and prospects, continues to beckon.

THE DIGITAL REVOLUTION AND THE REVOLUTION IN AMERICAN SCHOOLS

Despite the fact that policy makers, educators, and business leaders have advocated increased use of technology in education and training for decades, the true potential of technology to transform educational practice has rarely been fully realized. Today, technology renews its promise.

A newly wired nation with powerful digital capabilities has arrived with startling speed. Just two generations ago, computers were physically imposing but technically modest. They often took up entire rooms and cost a small fortune. In the single decade of the 1980s millions of personal computers made their appearance on desks and laps everywhere -- in factories, offices, homes, universities, airplanes, and schools -- accompanied by the facsimile machine and the mobile telephone. Low-cost, high-quality versions of each of these are easily within financial reach of many American households.

At the same time, a national information infrastructure capable of fully supporting this wired nation is rapidly being put into place. All of these developments foreshadow a new education and learning infrastructure for Americans, both in and out of school, for young and old alike.

Although this revolution in technology is far from complete, it is already clear that it promises educators, parents, and students unprecedented access to a wide spectrum of robust, sophisticated devices and networks capable of tailoring instruction to the needs of individual students, improving instructional management, expanding time for learning, and improving the working lives of teachers.

FINDINGS

Following months of analysis -- accompanied by in-depth conversations with teachers, principals, school administrators, parents and students, state and local policymakers, experts in technology, and other federal agencies -- five conclusions about teaching, learning and technology stand out:

- Properly used, technology is a powerful tool for learning.
- New technologies are essential to the success of the current effort to create better schools.
- Technology permits teaching and learning to be tailored to the needs of each student.
- Digital technologies are rapidly changing how we live, work, and play, but their full effects are only rarely felt in the classroom.
- Teachers must be given the time and training they need to take advantage of these new tools for teaching and learning.

Properly used, technology is a powerful tool for learning.

(SIDEBAR OF NORTHBROOK MIDDLE SCHOOL)

Several analyses indicate that, properly employed, implemented and supported, technology leads to superior learning.[5] The sidebars on the following pages summarize decades of the best research in this area. This research confirms what the best teachers and most thoughtful experts on technology have always known: under the right circumstances, and in the right hands, technology is a powerful tool for learning. Students learn more. They learn faster. And they are happier in their studies.

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[5] See, for example Barbara Means (ed.), *Technology and Education Reform: The Reality Behind the Promise*. San Francisco: Jossey Bass, 1994.

Pull Quote 8

Several considerations deserve special attention. First, technology is a tool, not an educational activity. It is a means to an end, not an end itself, and it has almost unlimited specific applications (see Table 1, below).

Table 1
Potential Uses of Technology in Support of Teaching and Learning

Use	Examples
Individual Learning	Stand-alone drill and practice CD-ROM or Internet-accessed data bases Communications with experts Word processing and spreadsheets Simulations to visualize mathematical and scientific concepts
Group Learning	E-mail for group communication Presentation software for group collaboration Video presentations Communications between classrooms for collaboration on projects
Instructional Management	Integration curriculum standards and assessments Management of student portfolios and exhibitions Development of student instructional plans and contracts
Communications	Expand access to expertise and resources connect parents, students, home and community from remote locations (e.g., rural schools)
Administration	Record keeping, attendance, accountability functions, and other administrative activities

It is clear that a computer can serve as a freestanding or networked work station. It can serve as a word processor or support desktop publishing. It can connect teams of students and teachers with others in the building or around the globe, and it can encourage communication among parents, students, and teachers. The point is that technology is a tool for learning, like a typewriter or a blackboard, not an educational treatment.

Second, most existing research focuses on past generations of technology. Researchers' understanding of the effectiveness of the latest technologies is limited. New capabilities promise to support more difficult learning tasks, to integrate many different kinds of media in support of learner-centered instruction, and to manage much more complex learning environments. Because these capabilities are so new and relatively untried, analysts have yet to demonstrate their success -- although these new tools are likely to be much more effective simply because they are so much more powerful.

Finally, as discussed below, emerging technologies readily adapt to learner preferences. Some students prefer written materials; some are more engaged when the information is presented visually, and some need to test out alternatives with computer models. Some begin with an idea and delve deeply while some wander through a rich variety of resources to find the right track. Some work independently while others seek collaborators, mentors and experts. Some like the ability to review and revise. Today's interactive technologies accommodate them all.

As the United States approaches a new century, it is the beneficiary of a remarkable, decade-long school reform movement. That movement, launched by the 1983 report of President Reagan's National Commission on Excellence in Education, *A Nation at Risk*, was sustained by President Bush's 1989 leadership in helping the nation's governors agree on National Education Goals; it culminated in 1994 Congressional passage of the Clinton Administration's *Goals 2000: Educate America Act*.

Goals 2000 establishes, for the first time, a learning reform model for the United States based on state and local standards of what students should know and be able to do. It expands and codifies the national education goals and promises top-down support for

bottom-up reform. Since enactment of that legislation, 48 states have participated in this unprecedented federal-state-local partnership.

The ambitious scope of this standards model is its most novel and impressive feature. It is grounded in the conviction that all students are entitled to a first-class education. As President Clinton has said, it is designed to "make every American child a winner."

Pull Quote 9

On the basis of practical experience and research, teachers, principals, cognitive scientists, and education theorists are all convinced that many of the skills most needed by today's graduates are best acquired in the course of performing real tasks involving the construction of real solutions to real problems. They argue persuasively that when such teaching strategies involving such tasks are harnessed to instruction that is learner-centered and responsive to individual needs, interests, and capabilities, almost all students can meet much higher expectations and perform at much higher levels .

If such learning environments are to come into being, expert opinion is unanimous: these environments can best be created by employing new and emerging technologies. In fact, most experts believe they cannot otherwise be achieved.

Technology permits teaching and learning to be tailored to the needs of each student.

Common sense tells us that tailoring education programs to the needs of individual students creates a host of difficulties for schools. It places new demands on teachers and school administrators, on students and parents. In contrast to today's school

in which the teacher is likely to say to 30 students: "All right class, let's turn to page 135 of the textbook," tomorrow's tailored programs could:

- define a learning program for each student based on the student's learning style and learning pace;
- keep track of the student's progress and be prepared to take remedial action (no matter how talented the student) in the event he or she lags too far from his or her specific learning goals;
- organize the school day so that students of varying ability, learning at different paces, have available the different amounts of time necessary to master each subject.

(SIDEBAR OF TAYLORSVILLE ELEMENTARY SCHOOL)

The very best teachers have always tried to do these things, but providing individual attention is very difficult in a class of 25 or 30 students. It is simply impossible for the 120 to 150 students that a secondary school teacher may see on any given day. The result is familiar to every student, graduate, parent, teacher, and administrator: Teachers pitch their lesson plans at the middle third of the class, provide whatever extra help they can to students in the bottom third, and leave the best and brightest to fend for themselves.

With suitable software, computers and affiliated technologies can tailor instruction to individual needs at an acceptable price, in effect reducing the student/teacher ratio. They can improve acquisition of basic skills; encourage the development of advanced skills and knowledge; help students (individually and in groups) conduct sophisticated projects developing advanced problem-solving skills; and assist students, parents, teachers, and administrators in tracking and maintaining an accessible record of student progress and performance (see "Making it Happen").

In brief, technology can help resolve one of the enduring dilemmas of public education in the United States: how to respect and respond to individual differences among students within the context of the common school.

Digital technologies are rapidly changing how we live, work, and play, but their full effects are only rarely felt in the classroom.

Practically every American has experienced how new and emerging technologies have dramatically changed our daily lives -- from cable and satellite television with their unparalleled viewing choices to the convenience of 24-hour-a-day automatic bank teller machines. Yet, despite the existence of large numbers of computers in the nation's schools, as well as our ability to identify "lighthouse" schools and school districts at the technological cutting edge, the full effects of technology are rarely felt in the typical classroom.

Personal Computers

Personal computers have penetrated schools with remarkable speed. Eleven years ago, the average school had one computer for every 125 students; by 1995, the average school had one computer for every 12 students. All told, the "installed base" of personal computers in schools was approximately four million during the 1994-95 school year.[6] The Software Publishers Association estimates that 55 percent of the installed base can be found in elementary schools (which comprise about 50 percent of all schools), 39 percent in secondary schools (which comprise about 31 percent of all schools), and the remainder in district offices.

These averages, however, conceal almost as much as they reveal. Senior high schools are likely to have more computers per student than elementary schools.[7] About

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[6] Quality Education Data, Inc. *Technology in Public Schools: QED's 13th Annual Census Study of Public School Technology.*
[7] QED, Op. Cit.

one-tenth of all the schools in the country have a computer for barely every 25 students; even fewer have a computer for every five students or less (see Table 2). As discussed later in this chapter, much of this equipment is a decade or more old and technically out of date.

Table 2
Distribution of Students Per Computer

Students per Computer	Schools (%)	Millions of Students	Percentage of all Students	Average # of Students per Computer
< 5	4	1.2	3	3.9
5 - 12.4	44	18.1	41	8.9
12.5 - 23	43	20.1	46	16.5
>23	9	4.4	10	28.5

Source: H.J. Becker, *Analysis of Trends of School Use of New Information Technology*. (Prepared for the Office of Technology Assessment, March 1994).

In sum, the school technology glass is half full. Significant progress has been made toward laying a decent foundation of personal computers in the nation's schools. The provision of an average of one computer for every 12 students is a significant accomplishment representing a ten-fold increase in computer density over eleven years.

Nonetheless, the glass remains half empty. More than half (56 percent) of all students are in schools unable to meet the national average of one computer for every 12 students -- and only about 3 percent of all students are enrolled in schools with a computer for every five(or fewer), students a density that advocates of school technology consider to be minimally adequate.

Other Technologies

Information on other technologies is more fragmented and difficult to locate. Data from a 1994 survey are presented in Table 3 below. What is apparent from this information is that most of the technologies surveyed, with the exception of cable

television, are available in less than one-third, of all schools and often in less than one fourth.

Table 3
Estimated Technology Usage
1993-94

	Districts	Schools
Cable TV	65%	70%
CD-ROMs	43	29
Local Area Networks (LANs)	43	23
Modems	41	29
Satellite Dishes	40	15
Videodisc Players	26	23

Source: Software Publisher's Association, July 1994

Connections to the Internet

The relatively low level of technology penetration overall appears to be confirmed by *A Survey of Advanced Telecommunications in U.S. Public Schools, K-12*, completed in 1995 by the National Center for Education Statistics. Based on data from a nationally representative sample of 1,380 public elementary and secondary schools in the Fall of 1994, the survey indicates that:

- only three percent of all instructional rooms (classrooms, labs, and media centers) in public schools are connected to the Internet;
- just 40 percent of the computers with telecommunication capabilities are located in classrooms (most presumably are in administrators' offices, libraries, or computer centers);
- schools with enrollments below 300 (typically rural) are much less likely to be on the Internet than schools with larger enrollments; and
- only about one-half of schools have access to the Internet or another wide area network (WAN), and in these schools teachers are seven times more likely than students to use the network -- and administrative use is nearly four times greater than student use;

- although two-thirds of public schools plan to implement or upgrade a wide area network (most as part of district plans), about the same proportion report inadequate funding as a barrier to the acquisition and use of advanced telecommunications.

In part these findings reflect not simply inadequate attention to the need for specific technologies but also significant gaps in the infrastructure necessary to support emerging technologies. Most computers do not run on batteries; they require electrical outlets. Stand-alone computers do not require telephone lines, but networked computers do.

Figure 1 displays the proportion of schools responding to a 1995 survey on the adequacy of the infrastructure (modems, wiring, and the like) in place to support technology. The results are fairly clear. Only about half of all schools report that they now have adequate power and wiring to handle their technology needs. Less than half believe they have sufficient networks, modems, and modem lines, less than 40 percent consider the number of electrical conduits satisfactory, and only 13 percent are satisfied with the fiber optic cabling available.

Figure 1 here

In short, these surveys indicate that although educators have made a lot of progress, they still have a long way to go. Schools are not yet full partners in the broad digital revolution that is transforming American work and life.

Teachers must be given the time and training they need to take advantage of these new tools for teaching and learning.

Too much of the discussion of technology and education (at national, state, and local levels) has taken place with little more than lip service to the needs of teachers. The attitude appears to be that if technology is provided, teachers will use it.

The vast majority of teachers lack time to come up to speed with new developments in technology and have little access to the latest technologies. New teachers fresh out of schools of education have rarely had the benefit of pre-service training in technology. For all practical purposes, there are few models in place of effective and conscious use of technology-rich schools to improve learning and achievement.

Schools spend a far smaller percentage of their revenues investing in technological innovation and improving the quality of their human resources (teachers and administrators) than does practically any other comparable enterprise. Figure 2 shows a recent estimate of the school spending mix on technology.

Figure 2 Here

Focus groups conducted as part of this report reinforce this. The general public believes that technology already in schools is not being used properly, and parents believe that at least part of the reason is that teachers need more training.

Pull Quote 2

Only real training -- not an occasional afternoon "workshop" of ten minutes with an orientation disk -- can empower teachers to use these new tools. Without such

training, teachers may fall victim to the kind of frustration which often surfaced in the Department's workshops, meetings, and on-line discussions with educators, students, employers, and parents. Many teachers have grown increasingly resistant to what they consider to be reform fads, with each new innovation being dismissed as nothing more than the latest "reform of the month."

Technology, like many other valuable reform suggestions, is caught up in this skepticism. These new tools can fulfill their full promise only when teachers are fully trained in their use, have the time to use them effectively, and enjoy the support other professionals receive to develop their skills.

BASIC REALITIES

The conclusions above -- the effectiveness of technology, the importance of technology to reform, the need to tailor instruction to the student, startling deficiencies in the school technology base, and the importance of professional development -- are significant. Equally important are a number of basic realities circumscribing technology policy.

These realities will govern educational technology policy, and among them are the following:

- Technology is far more than just another fad; its availability, or lack thereof, will profoundly influence socioeconomic divisions in the United States.
- Costs are a significant issue but not the principal problem.
- The relative immaturity of new technologies means that schools are planning amidst rapid change.

- The main technological problem for schools is identical to the corporation's technology problem, which is the need to rethink organization and processes.

Technology is far more than just another fad; its availability, or lack thereof, will profoundly influence socioeconomic divisions in the United States.

Today, unequal access to computers and telecommunications is deepening divisions in society and reinforcing family status and background as key determinants of student performance. Without conscious attention to this issue, the growing power of technology seems destined to maintain, and perhaps expand, distinctions between the education "haves" and the education "have-nots."

Pull Quote 17

Although recent data suggest that schools in wealthier communities do not enjoy markedly greater access to computers and other technologies, it is also undeniably true that household possession of computers -- and use of modems, CD-ROMs, and network services -- is heavily skewed towards middle- and upper-middle-class homes. Many of these families, including some with relatively modest incomes, have already voted with their own scarce dollars to invest in technology for their children, often at considerable financial sacrifice.

But what about homes where real poverty stands in the way? The latest information from the Bureau of the Census and the National Telecommunications and Information Administration (both in the Department of Commerce) confirms what many suspect: low-income citizens and minority Americans, urban and rural, are much less likely to own computers than their more affluent or majority peers.

Figure 3 Here

As Figure 3 demonstrates: white and Asian Americans are two or three times as likely to own computers as African-American or Hispanic citizens, and six or seven times more likely to own them than the rural poor, whatever their ethnic background.

To the extent that the vision of the use of technology to extend learning into the community and the home is realized, the effects of family background on student performance will be reinforced unless policymakers attend to the issue at the outset.

Costs are a significant issue but not the principal problem.

Conventional wisdom holds that lack of money is the primary obstacle to getting more computers and other technologies into schools. In fact, although money is an issue, it is not the principal problem.

Pull Quote 13

In some communities, particularly low-income rural and inner-city school districts, funds for computers and other technologies are difficult to acquire. But many communities have succeeded in financing ambitious hardware acquisition programs through special levies or partnerships with local businesses.

At the request of the Department of Education, the RAND Corporation projected the annual costs of providing many more computers, and much more up-to-date equipment, in all of the nation's schools. In eight technology-rich schools (five of which provided one computer for every three students or less), RAND researchers observed that the annual technology costs (with the hardware cost amortized are five years) ranged

from $141 to $490 per student.[8] The smallest of these schools enrolls 310 students; the largest, 1,800.

The amortization of these costs is significant, since schools, like private firms, need to develop an investment mentality for technology based on the understanding that new technologies involve not simply a one-time, up-front cost for equipment but also on-going, recurrent expenses. These recurrent expenses involve costs to upgrade hardware and software, maintain special furniture and cabling, replace materials and supplies, and continuously upgrade the skills and competence of teachers and administrators.

In light of these considerations, RAND analyzed each school's current equipment inventory using the following cost elements: current prices for all computer hardware and software, amortized over five years; special infrastructure such as furniture and cabling amortized over ten years; initial teacher preparation amortized over five years, along with costs of new technology support personnel; and materials and supplies treated as an annual expense.

Table 4 outlines the average, annual, amortized expenses for significant costs elements across the eight schools.

Table 4
Average, Annual, Amortized
Expenses in Eight Technology-Rich Schools

Element	Average Annual School Expense	% of Total
Hardware	$129,900	46%
Software	20,200	8
Infrastructure	13,700	5
Professional Development	27, 600	10

[8] The range very closely reflected the number of students per computer in these schools. The school with the lowest cost per student provided one computer for every 11 students (near the national average); the school with the highest cost provided a computer for every 1.5 students.

Technology Support (Personnel)	66,000	27
Materials	10,000	4
Weighted Per-Pupil Cost	$274	100%

Table 5, below, compares with current spending levels the costs of two national scenarios for increased technology spending. (Current spending on technology were estimated by RAND to be $3.1 billion in the 1994-95 school year, or 1.3 percent of expenditures devoted to education.)

The low alternative assumes annual per-student spending of $180 -- near the low end of RAND's sample of eight technology-rich schools. The high alternative calls for spending about $450 per student (near the top of the eight schools) on all students.

Table 5
Current Technology Spending and Four Alternatives

Model	Per-Pupil Expenditures	% of Education Spending	Total Expenditures
Current	$70-80	1.3%	$3.1 billion
Low	$180	3.0%	$7.5 billion
High	$450	7.5%	$18.5 billion

At first blush, each of these alternatives is daunting. However, schools are not starting from scratch; they are already spending over $3 billion on technology. The low alternative seems achievable. Increasing technology expenditures to about 3.0 to 3.5 percent of all school spending is within reach if current increases in educational technology spending continue. According to a McKinsey & Co. analysis for the National Information Infrastructure Advisory Council, technology will reach 2.1% of total education spending by the year 2000 if the current growth rate of 16.5% continues.[9]

[9]From information submitted to the National Information Infrastructure Advisory Council by McKinsey & Co., October 1995.

education spending by the year 2000 if the current growth rate of 16.5% continues.[9] Although schools have a lot of technological ground to make up, devoting 3.0 to 3.5 percent of spending on technology requires educators to do only a little more than what they are already doing and are inclined to do.

In short, the best estimates indicate that although costs will continue to be a problem, they represent a solvable problem.

The relative immaturity of new technologies means that schools are planning amidst rapid change.

The novelty of many of the nation's new digital capabilities, combined with the fact that they are rapidly expanding, growing, and becoming more powerful, are signals of the relative immaturity of the technologies themselves. This situation creates a host of inter-related problems for schools including, most prominently, great diversity and variability in school equipment; frustrating, apparently arbitrary technical walls between different pieces of equipment and different software; and a school market that software developers find unattractive, largely because it does not offer economies of scale.

Pull Quote 14

(SIDEBAR ON COMPUTER CLUB)

Diversity and Variability. The computers in America's schools are very diverse. Many of them are also very old, and technically out of date. As Figure 4 indicates, school districts are using computers produced by practically every conceivable manufacturer for both administrative and instructional purposes.

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[9]From information submitted to the National Information Infrastructure Advisory Council by McKinsey & Co., October 1995.

Figure 4 Here

Over half of this equipment embodies technology that is a decade or more old. Although these computers remain useful for certain purposes, they are very limited by today's standards and working with them is inherently frustrating. Older computers, and the operating systems and tools embedded in them, cannot use the latest multimedia software and most cannot perform on the network. Because these older computers are rarely used in businesses and homes, software developers understandably do not pay much attention to developing software and peripherals for them. Despite their lack of suitability for emerging software and applications, however, their very presence in schools makes it difficult to persuade some taxpayers that more computers are needed.

Arbitrary Technical Walls. The diversity and variability of existing equipment is directly related to the second problem, the existence of apparently arbitrary walls between computers and systems.

This very real problem is caused, for the most part, by the inability of particular pieces of equipment, developed by different manufacturers with different operating systems, tools, and software, to "shake hands" with other equipment and its operating systems, tools, and software, that is, to work with products developed by other manufacturers. Apples, Macintoshes and IBM and IBM-compatible equipment still require different operating systems and different codes, and use different peripherals in different ways. As if this were not challenge enough, computers of different vintages produced by the same manufacturers are often quite incompatible.

In the long run, this is a very solvable technical problem that experts refer to as the need to develop and implement common "interoperability standards." And it is an issue that extends far beyond the school walls, vexing computer users at home as well as

in large corporations and small and medium-sized businesses.[10] Because it is a universal problem, universal solutions will be developed. Indeed, there are already signs that solutions to the interoperability standards issue are at hand. For example, standards for software make it possible for some CD-ROM software to run on both Macintosh and Windows "platforms." Standards for communication among diverse computers across networks have already enabled Internet applications like electronic mail and the World Wide Web to grow by leaps and bounds.

Unattractive School Market. The diversity of the installed base and the arbitrary walls between various systems contributes directly to the third problem: a market for school materials that provides very few incentives for developers to invest in education software.

Pull Quote 15

School and home education markets are fundamentally different. The home education market is very high volume, with low margins and advanced production features (animation, graphics, sound, music, film, color, and the like). The school market tends to be low volume, high margin, with production values described as similar to the quality of 1950s black-and-white television. The importance of high-quality, high-production-value, content software is undeniable if technology is to fulfill its promise in the schools. If content software is to replace textbooks, or to supplement them in significant ways, it must also offer curricular coherence -- a structure or framework for

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[10] *Business Week*'s "Annual Report on Information Technology" (June 26, 1995) reports that although private sector sales of communications equipment are booming and corporate networks are pervasive, "the benefits are maddeningly elusive...." According to the report: "[I]t's still tough to cobble together a high-speed network over large distances.... The complexity of putting all the technology together is enough to send managers screaming for pencil, paper, and stamps. For the network to operate smoothly, everything on it must adhere to consistent hardware and software standards and communications protocols. This goes beyond whether to buy IBM or Apple, Windows or OS/2. You have to worry about bridges and routers that connect LANS in different departments, modems and gateway computers that move data to the outside world, and the PBX that routes phone calls."

teachers and students -- similar to that performed today by textbooks and textbook series. Earlier, learner-centered reforms (sharing visions similar to those of technology advocates today) foundered on the failure to achieve and demonstrate such coherence; so will technological reform if high-content, high-quality, coherent software does not become available.

Market size is also a major issue. The potential market for software marketed to the home is limited only by the number of households with computers in the United States -- now about 30 million homes and growing rapidly. The potential market for education software is limited to about 2 million classrooms in 110,000 schools. Although nearly ten million new computers will be installed in homes this year, less than one million new computers will be installed in schools.

The main technological problem for schools is identical to the corporation's technology problem, the need to rethink organization and processes.

Most comparisons of schools with private firms overlook major differences between the two, but in at least one area instructive comparisons are possible. Private sector leaders have learned that new technologies profoundly change the nature of work, whether on the factory floor or in an office or service establishment.

Pull Quote 16

In the new work environment, human resources and skills, as well as corporate organization and processes, have had to change as well. Modern firms require large numbers of highly skilled, reliable, well-educated workers—people who understand and use new forms of information and new technologies, who can adapt to change, and who can work efficiently with others. All of this has come as something of a shock to the

corporate system, a blow to traditional sensibilities about the nature of work and the proper relationships between work, worker, and supervisor.

In response, corporations have invested massively in their human resources, and in rethinking roles, responsibilities, and processes within the corporation.

Schools are slowly learning the same lessons. Stimulated by school reform efforts and assisted by external grants, some schools can be found that have made a very large investment in technology as part of a reform process aimed at "changing the culture of the school."

This process often involves substantial use of project-based instruction; new approaches to student assessment, often emphasizing portfolios; cooperative teaching over blocks of time which greatly exceed the typical 50-minute class; and a very substantial investment in teacher preparation. Perhaps most important, effective use of technology, even in a fairly traditional setting, requires the investment of considerable time by teachers. Lesson plans must be revised, new materials must be sought or created, and traditional routines altered.

In short, a reformed and restructured school using technology must be willing to rethink processes and organization as it invests in new methods and technologies. As in the private sector, all of these changes come as something of a shock to the education system -- a blow to the sensibilities of the typical educator about the nature of learning and the proper relationships among students, teachers, and administrators.

LOOKING TO THE FUTURE

The truth is that powerful new technologies are now available, and more are on the horizon, to help create the basics for better education in the 21st century. By raising expectations, adding the best teaching and the latest technologies to the classroom, and

redefining how we teach and where, our young people can be prepared for the challenges the future will place before them.

Looking to the future, it seems clear that technology can free learning from many of the limitations of our institutions. It can provide knowledge and information, and sharpen skills, wherever and whenever they are needed. It has the potential for extending the time devoted to learning not only by promoting more effective use of school time but, perhaps more importantly, by extending learning activities beyond the school walls and into the community.

Pull Quote 12

Technology's most fascinating promise is that it can create teaching and learning environments not previously possible. Simulated environments (virtual reality) can provide safe places for scientific experimentation, realistic markets in which to conduct business, and imaginary worlds that engage and motivate young learners.

These new applications cannot be expected to function if they are simply an "add-on" to today's schools. They call for a new kind of school, one that is not bound by the traditional 50-minute period and the six-hour school day, one that encourages teams of teachers working with the same group of students over extended periods of time (whether hours, days, weeks, months, or even years), one that extends learning into the community and into the home.

Many of the most exciting innovations in today's schools embody these very changes. But these changes represent the exception rather than the rule. If the full potential of technology to transform education is to be met, the transformation will come about not by happenstance, but through the development of a careful plan that explores

where we want to go and how we plan to get there, and examines what works and how to duplicate successful practice.

ELEMENTS OF A STRATEGIC PLAN

Creating a broad, national plan to realize the promise of technology in the classroom is both a challenge and an opportunity. It is a challenge because the nation is shooting at a moving target from a moving platform. A great deal of diversity and unevenness in technology implementation exists around the nation. Conflicting views of the appropriate role of the federal government in education complicate the conversation. The rapidity with which technology evolves requires attention. And the centrality of the private sector in technology demands respect.

But the nation also confronts a unique opportunity, presenting itself at a unique time. As the United States approaches a new century, a well-formulated consensus exists on the significance of technology to the future of the nation's children. States, localities, and the private sector have made remarkable progress. Now is the time to cement that progress into place, building on it to secure the nation's economic and educational future.

Most states have made impressive contributions to upgrading their schools' technology base. Frequently motivated by participation in Goals 2000, often acting on their own reform initiatives, sometimes responding to the demands of local teachers and administrators, state activities range from building state infrastructure by connecting schools to the Internet to the establishment of statewide technology centers and dissemination strategies. More must be done, much more, but simply as an illustration of the magnitude, diversity, and scope of ongoing state efforts, Table 6 outlines different activities in several states.

State-Level Strategies for Supporting Technology in Schools

The Delaware Center for Educational Technology, created by state legislation, is spending $30 million in state money to wire all 7,000 Delaware classrooms with fiber optic cable by the fall of 1997. In addition, federal Goals 2000 funds will subsidize the costs of buying some computers for schools, reducing the disparity between wealthy and poorly-funded school districts. Outdated computers will be updated or replaced. "Student education has always been limited by what materials their schools can afford," says State Representative Joe Petrilli (R-New Castle). "But the Delaware Education Network will bring the resources of the entire world as close as the nearest computer screen. Students won't have to wait until the next edition of a textbook to learn the latest information. They will have instant access to a new world of up-to-date facts and current events."

In more than a dozen states, regulatory commissions require preferential rates on telecommunications services for schools. **Louisiana** requires that schools be charged at the residential rate rather than commercial rates. In **Missouri**, educational institutions receive a 20% discount. In **Texas**, telecommunications services for distance learning must be provided at rates 25% below the normal charges.

California, Georgia, Mississippi, Missouri, Nebraska, and **South Carolina** have all earmarked state revenue for technology in schools. For six years, **Missouri** has used an earmarked tax on videotape rentals to provide funding for satellite dishes on schools, satellite course fees, laser disc players, and other educational uses. Revenue is about $4 million per year. Since 1986, lottery funds have provided another $5 million per year distributed by competitive grants to school districts that can be used for technology.

Kentucky's "master plan for education technology," released in 1992, calls for a communication system for voice, video, and data that will interconnect every school's computers in the state. The plan calls for a telephone in each classroom, a computer for every six students, and a portable computer for each teacher. The total cost is expected to be $560 million over six years. So far, $137 million has been spent by states and districts. In 1994, the state won a $4 million grant from the federal Department of Education to build its distance learning network.

Ohio has launched a five-year, $95 million set of bond issues to support educational technology. These funds will be used to wire every classroom in the state to support voice, data, and interactive video communications. Almost half of these funds will support equipment purchases for the poorest 25% of schools.

Illinois, Maryland, South Carolina, and **Wisconsin** have statewide foundations that raise funds for technology. The Corporation for Educational Technology in **Indiana** raises money from the state and from private sources and uses it to promote learning outside the classroom by helping families install learning technologies in their homes.

The Idaho legislature appropriated $14 million for 1994-95 educational technology expenditures under the Idaho Technology Act. Of the $14 million, $10.4 million goes to K-12 schools by formula to support technology in the classroom. $3 million was distributed through a competitive grant program. The legislation suggested that districts spend 50% of the funding on hardware, 25% on software and 25% on training. All Idaho schools should be connected to the Internet within three years.

Florida has increased appropriations for school technology from $5 million in 1993 to $135 million in 1994 and $117 million in 1995.

Source: telephone interviews with the state technology coordinators; Quality Education Data, Inc., *Networks Now, 1995: Survey of How States Use Telecommunications Networks in Education.*

At the local level an impressive array of activities is also underway. For example, the Central Kitsap Schools of Silverdale, Washington initiated a technology demonstration of technology in support of a "culture of learning" that was so successful district citizens extended the demonstration district-wide. Teachers, administrators, students, parents, and clerical and janitorial staff will share the same network. New York's 717 school districts spent more than $360 million on technology in 1993, according to state officials, an average of more than $500,000 per district. The public schools of Perry, Ohio have created a "community education village" that provides universal access to local, national, and global information sources from the home or the school.

At the same time, the private sector is also a major, perhaps the primary, influence in this entire area. Computer, telephone, cable, and wireless communications companies are well on their way to finishing construction of the information superhighway and most are committed to building linkages to schools. Software companies, textbook publishers, on-line services and other commercial providers of educational "content" turn out a dazzling and ever-expanding array of new tools and products -- and most are intensely interested in the potential of the education market.

What is required in this situation is not just a national plan developed by the federal government. What is needed is a clear picture of where the nation is and where it needs to go -- a set of national priorities and strategies designed to draw together all of this energy and focus it relentlessly on the task of providing the best and most up-to-date technologies in the nation's classrooms.

A SUMMARY: WHERE WE ARE

Since 1980, the nation's schools and school systems have steadily added to their base of technology. They have recently done so at an accelerating rate. The motivation

for these additions? Most often to provide students with skills in the use of technologies that are central to the workplaces of today and tomorrow.

In addition, a small proportion of the nation's schools (about four percent) have intensively and effectively implemented a variety of educational technologies in ways that engage and motivate students to achieve performance levels consistent with the high standards of the nation's education goals.

On the basis of the experience of these schools, anecdotal evidence, and numerous smaller applications of technology, it seems clear that technology promises to give a powerful boost to today's school reform agenda. Indeed, this agenda may not be achievable without the use of these technologies.

However, several barriers block the path ahead. Some of the most critical of these barriers were discussed in the prior chapter: Teachers need training and opportunities for professional development. Costs are significant, ranging upward of three to five percent of operating budgets on a continuing basis. High-quality content software is scarce and hard to find. The nation needs a strategy to surmount these barriers, overcome them, or knock them down.

STRATEGIC ELEMENTS: WHERE WE NEED TO GO

Against that backdrop, it is clear from conversations and discussions with parents and educators that they are correct in asking for a strategic focus on three elements:

1. Training teachers.
2. Equipping and connecting schools.
3. Providing schools with high-quality content software.

Parents, teachers, and administrators want many other important things from schools. They want order, discipline, and high standards. They want their children prepared for life's demands. They want teacher training that is the latest and most up-to-date -- and up-to-speed with today's theories. And they want to make sure that past and current investments in technology serve them well in the future.

But the heart of their concerns about technology revolves around teachers, technology infrastructure, and curriculum products -- the very problems identified by analysts as most significant. These issues possess the additional advantage of being readily quantifiable. Parents, educators, and public officials can evaluate how many teachers have been provided with the training they need. They can count how many schools and classrooms have access to the information superhighway -- and measure the quality, power, and capabilities of equipment available to teachers and students. And they can make judgments, no matter how rough, about the quality of curriculum software.

To respond to these concerns, this plan identifies three strategic objectives. First, providing teachers with the skills they need to use technology. Second, making the necessary investments in equipment and connections to the information superhighway. Third, expanding the market for software and other curriculum products so that these new tools are readily available in schools and homes.

The final section of this chapter outlines what the federal government is prepared to do to advance these strategic objectives. There is little novel in this list of federal commitments. The tasks proposed are very traditional roles of the federal government, with an emphasis on improving performance of these roles rather than adding new ones.

Strategic Objective One
Train Teachers

By the year 2000, all of the nation's teachers will have received the training they need to develop the skills required to use technology for effective teaching and learning.

(SIDEBAR ON "ELEMENTS OF SUCCESSFUL PROFESSIONAL DEVELOPMENT FOR TECH")

As noted above, one of the most significant barriers to greater use of technology in schools is that most teachers have had little training in it and little support in its use. This strategic objective is designed to insure that by the year 2000 every classroom teacher in the United States (about 2.9 million) will have had the opportunity to benefit from first-class training on the latest and most up-to-date technologies available for the classroom. It is intended to make sure that teachers are familiar with how to use computer networks -- and are using them -- to obtain access to information, communicate with their colleagues, develop their own skills, and use computers to enhance student learning.

At first blush, this represents a daunting challenge. It is, however, well within the nation's grasp. Presently about ten percent of all teachers are thought to be proficient users of educational technology. How do we reach the other 90 percent?

Institutions of higher education represent a first line of attack. Each year, about 120,000 men and women in the United States receive a teaching degree.[11] Over five years, half a million teachers can receive the professional development opportunities they need if technology is infused into the curriculum of schools of education.

Many states play a large role in encouraging professional development. Florida requires districts applying for some state technology funds to set aside 30 percent of their awards for training. The state of Washington spends about 40 percent of its educational technology budget on teacher training.[12] Eighteen states require training in computers or technology for all teachers seeking certification, a 50 percent increase since 1987. And at least 37 states have statewide electronic networks for educators, providing online courses for teachers and resources such as lesson plans, on-line conferences, and curriculum materials like CNN Newsroom and PBS Online.[13]

School districts, too, can step up to the plate. The most significant source of financial support for teacher professional development can be found in district salary agreements tying salary increases to the completion of additional college credits. These salary increases should be tied to completing at least some minimal portion of this coursework in technology-related professional development.

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[11]National Center for Education Statistics. Digest of Education Statistics, 1994, p. 252-3.
[12]"Office of Technology Assessment. *Teachers & Technology: Making the Connection*, p.137
[13]Quality Education Data. *Network Now 1995*, p. 6

Strategic Objective Two
Equip and Connect Schools

By the year 2000, all 110,000 schools in the nation will have technology-rich classrooms equipped with computers and access to the information superhighway.

In its broadest terms, the national objective defined in Chapter 1 by the Secretary is to create a learning system that permits all of our people, young and old, to learn *whatever* they need to, *whenever* they want to, *wherever* they choose to. Such a system cannot be created until access to the information highway is universally available through schools, libraries, and community centers.

As noted in Chapter 2, although costs are an issue, they are not the critical problem -- either in terms of connecting schools to the information highway or providing schools with access to sufficient computers. A much more challenging set of issues revolves around changing the culture of the school, incorporating technology into school improvement efforts, determining school "connectivity" needs (for both new buildings and retro-fitting of existing buildings, including buildings with asbestos problems), and establishing a regulatory framework in telecommunications to encourage and support educational access at reduced rates.

Several of these issues can be resolved readily enough at the state and local levels, assuming adequate communications between state and local officials and the private sector. Some (e.g., telecommunications policy) are directly governed by federal statutes. All of them can benefit from consistent policy direction from national officials working with their colleagues at the state and local levels and in the private sector.

Where will schools find the money? Federal sources currently provide close to $1 billion annually (about half of that amount from Title I) for technology, or about one-

third of all school technology spending. Whatever the actual dollar levels of future federal support, if school spending on technology continues its present rate of increase of 16 percent per year, the federal proportion of expenditures will undoubtedly decline.

Most funding for technology, like most funding for education, will continue to come from state and local sources. Based on the experience of pioneer schools (the four percent of schools with access to the information superhighway and a very high density of computers per student), state and local educators can follow a tried-and-true strategy:

- **Develop a strategy for reaching every school.** It is not possible to do everything at once. One strategy is to start by investing intensively in a few schools or areas, building on their successes and learning from their failures.
- **Build public support.** Most parents and business leaders understand the importance of technology in schools since they either use it on the job or know that their children will in the future. But educators need to think seriously about engaging the broader public -- parents and non-parents alike -- in the task of sustaining long-term commitment to technology investments.
- **Develop an investment mentality.** A long-term investment mentality is needed if technology is to succeed over the long haul. As educators learn from their experiences in implementing new technologies, they can expand the number of schools involved while building into budgets the funds needed to maintain, upgrade, and sustain technology on an on-going basis.

While these strategies are helpful, they say little about how to finance them. States have drawn on direct appropriations, bond issues, lottery funds, and other sources. School districts rely on property taxes, bonds, and leasing arrangements. Most pioneer schools have relied on corporate or philanthropic gifts, or drawn on flexible categorical

federal funds for special student populations such as (disadvantaged students, students with limited ability or students with disabilities) or Goals 2000 funding.

Regardless of the source of funding, some visionary schools have created special public-private investment foundations which, over a period of several years, pool money from local sources, state revenues, federal funds, and the private sector to finance technology and other reforms. This approach appears to be the wave of the future and deserves serious consideration by districts and states.

Strategic Objective Three

Provide the Tools and Software Schools Need

By the year 2000, high-quality software and programming that meets the educational standards developed by schools, localities, and states will be readily available.

(SIDEBAR ON DALTON SCHOOL)

Many studies indicate that, properly used, technology-enriched classrooms promote better learning. Yet software developers report there is little demand for high-quality software and applications to support learning, too much variability in the hardware and systems in use in schools, and little reason to invest scarce private research and development dollars in the development of such materials.

States and school districts are the chief sources of funds for purchasing curriculum materials, including software. They are also responsible for determining what students should know and be able to do. They are, therefore, key players in the development of content software and programming. Among the best methods to stimulate the creation of high-quality curriculum tools:

> **Rigorously evaluate software.** Teachers need help identifying which products will help them in the classroom. Using state and local education standards as a guide, educators can evaluate products,

publish parents' and teachers' reviews of products, and otherwise disseminate information about software.

Aggregate demand to increase purchasing power. Software publishers are more likely to sell software at discounted rates and tailor software to specific educational needs if it is purchased in large quantities at the state or district level. Some states have entered into partnerships with software developers to get what they need and want.

At the same time, the private sector is presently *the critical actor* in the software and programming area. Publishers and software developers develop the products. Their best opportunity to lead in the development of the next generation of learning tools includes the following strategies:

- **Collaborate with educators**. Companies can benefit by forming partnerships with schools and school districts to train teachers, test products and ensure their utility in the real world of the classroom.
- **Rely on state and local content standards**. Content standards define challenging goals for what students should know and be able to do. By using well-established standards as a basis for product development, companies can be assured of a sufficiently large market for their products. For example, the mathematics standards of the National Council of Teachers of Mathematics are widely used by states and localities, and curriculum materials can readily be produced to reach this ready market. Similar standards exist in civics and government, geography, and the arts.
- **Take advantage of the latest research.** In the past few years, major advances have been made in our understanding of how children learn. Private sector firms should make full use of this knowledge while developing multi-media learning tools. (While much of this research was supported by the federal government, some firms, such as Apple Computer Inc., have supported their own research to better understand how technology could be used to help children learn.)

In short, training teachers is essential. Connecting and equipping schools is important. But neither is likely to achieve maximum effect without a ready and steady supply of high-quality educational content.

THE FEDERAL ROLE

In each of the three strategic areas above, the federal government has a limited, but absolutely essential, role to play.

First it is necessary to state the obvious. The most crucial decisions about technology will be made not by the federal government but by state and local leaders and the private sector. Education and training are being provided by such an array of public and private schools, colleges, firms, and individuals, that is defies easy description. In terms of public schools, most leadership efforts at the state and local levels are focused not on technology as such, but on system-wide school reform developed around higher expectations for student and school performance.

At the same time, computers, operating systems, software, and other new technologies are shaped by a powerful private sector, including telephone and cable companies, numerous manufacturers of computers, video equipment and related hardware, and the rapidly changing entertainment and publishing industries.

Unless federal technology policies and programs are framed with a clear recognition of these realities, they are almost certainly destined to founder. Federal actions and funds will have the greatest effect if they consciously attempt to shape and nurture the much larger expenditures of these non-federal actors.

In this connection, a very traditional federal role in education serves the nation well. It is a tradition defined in 1983 in *A Nation at Risk*, the report of President Reagan's National Commission on Excellence in Education. It is a tradition stretching

back to President Lincoln and the establishment of land-grant colleges and universities, back, in fact, to the Founding Fathers whose Northwest Ordinance provided for public schools on the frontier.

That tradition encompasses advocacy and leadership in school reform; developing and disseminating better information; establishing assistance organizations; and supporting research and development. The federal government should continue to call for better, more efficient, and more effective use of technology in schools and for telecommunications policies to advance that goal. The National Center on Education Statistics should continue to monitor school technology implementation.

The Department's regional educational laboratories and research centers should intensify their efforts to help local schools adapt and employ technology. And federal education research -- whether supported by the Department of Education, the National Science Foundation, or other agencies -- should redouble its attention to the educational effectiveness of well-implemented school technologies.

Against that backdrop, and in the context of the three strategic objectives defined above, this plan commits the Department of Education to several major activities:

A Summit on Teaching and Technology. To provide greater visibility to the effort to train every teacher in the use of technology by the year 2000, the Secretary of Education -- in partnership with governors, state and local educators, teacher associations and national organizations, and leaders from the private sector -- will convene a National Summit on Teaching and Technology. At the top of the summit's agenda: how to improve teacher preparation and "scale up" existing efforts to reach more teachers.

A significant portion of the Summit's work will also be devoted to such topics as: the use of technology to provide professional development; changing state certification requirements for teachers; providing individual grants for teachers; integrating

technology into the curriculum and into standards-based reform; expanding state networks for teachers, and providing teachers with the time they need to develop new skills.

A New Emphasis on Standards-Based Reform and Technology. The Department of Education's Challenge Grants for Technology in Education support innovative uses of technology, including partnerships and implementing new technologies. In making awards under this program, the Department is committed to selecting applicants whose definition of technological needs grows out of their understanding of education and learning needs. The Department will continue this emphasis and, as part of the national movement to encourage standards-based reform, will encourage districts to relate their technology expenditures to implementing new content-standards reform.

Financing Technology. The federal government can help schools to finance technology in two ways. First, several major categorical programs provide resources that can be used flexibly at the local level to support technology. These include Title I, the Eisenhower Professional Development Program, Goals 2000, and several others.

Second, the federal government is in an excellent position to survey activities across districts and states to understand what is working and the pitfalls and barriers that block implementation. In particular, the Department will examine how states, districts, and technology companies finance investments in technology, explore new alternatives with them, and issue a report by December of 1995. The six Regional Technology Consortia (RTCs) will work directly with states and districts to provide ongoing assistance, working with other federally-funded research and assistance centers.

Telecommunications Policies. The Federal Communications Commission and the Department of Commerce are working with the private sector and leaders in Congress

to help get schools connected. Important options to consider are special rate structures for schools; allocation of radio spectrum for educational uses; and public-private partnerships. The Department of Education will examine these and other options (with the help of state regulators and state and local education leaders), and report on the most successful strategies.

A Forum on Education Software. As noted above, the development of high-quality software depends on developing and nurturing much greater cooperation and collaboration between educators and the private sector. To that end, the Department commits itself to supporting a regular, on-going conversation through a series of workshops involving state and local educators, researchers, publishers, software developers, on-line services, cable and wireless operators, and other commercial providers of educational materials and "edutainment." The purpose? To bring together groups that have for too long been too far apart -- and to direct their attention to the need for a new generation of educational materials for a new time.

Effective Research and Development. Nowhere does the traditional federal role of supporting research and development demonstrate a better track record -- or promise better results -- than in the area of educational technology. By any standard, the federal record in this area is remarkable. Examples include the Internet, Mosaic (a software package used to explore the World Wide Web), high-performance computing tools, new understandings of neurology and cognition, and technological tools for disabled learners.

To build on this foundation, the Department of Education and other federal agencies have committed themselves to implementing a federal R&D strategy through 1999 which has already been developed and published by the White House National Science and Technology Council's Committee on Educational Training. This strategy focuses on: R&D to improve learning, evaluations to assess the effectiveness of new

learning technologies and techniques, exemplary models of cost-effective learning through the use of technology, and dissemination of information.

Voluntary Efforts. The Department of Education will lend its support to a range of voluntary and community efforts to support technology in schools. Those with technology expertise can help by wiring schools and training teachers. Students are also critical ingredients to the success of technology because they can help with maintenance, training, and support. And businesses can be of help by donating quality equipment and services to schools. These efforts are worthy of support and encouragement through awards, recognition, and other means.

FROM VISION TO REALITY

In the end, this document is really about only one thing: How best to prepare American children today for demands they will face as adults tomorrow.

In the first chapter, Secretary Riley presented an overview of how technology is changing our daily lives and a vision of how it can improve learning. That vision is well within our grasp if we have the will to reach for it. It will not, however, come into being through wishful thinking. Turning the vision into a reality will require long and hard work from American citizens, parents, teachers and administrators, and community and business leaders.

Throughout conversations with teachers, administrators, students, and parents, two perceptions stood out: People understand that technology is pervasive and that young people need access to it. The public also understands that American children face the challenge of change.

In recent decades powerful new forces have transformed the economies of the nation and the world. From the board room to the factory floor, from the executive suite

to the service desk, from the school to the home, roles, functions, and responsibilities have changed dramatically. Today's students will have to prosper in this new and different world. The challenges they face are real and sobering; they cannot be wished away.

These challenges will be met in the nation's classrooms. No issue is of more profound importance for the United States as it approaches a new century than the quality of its schools and the standards of performance to which its students are held.

As the nation takes up this task, technology represents educators' most promising new ally in the effort to reshape schools around realistic and demanding state and local standards for student performance. The power and versatility of new generations of personal computers harnessed to the magic of modern telecommunications can create a new kind of school for a new century.

In the 21st Century, the new American school will follow the finest traditions of its predecessors. It will be second-to-none in the world. It will empower each of its students to follow his or her dreams. It will demand excellence and it will guarantee equity.

This new school will differ dramatically from the Industrial School or the one-room Prairie Schoolhouse, not so much in goals or substance but in the tools used to pursue them. It will rely more on communications and computing technologies to support new levels of student learning, creativity, and research. It will encourage teachers to become mentors, coaches, and allies, instead of lecturers in front of the classroom. It will help students become active, curious producers of knowledge and lifelong learners, not passive receptacles of whatever the teacher says and the textbook offers.

This new school will transcend its own boundaries as it reaches into the community. It will ask parents to play a major role in the education of their children and to extend learning into the home. It will offer the opportunity to rebuild not only home-school connections but also a sense of community, one that engages parents, schools, citizens, community organizations and business leaders and creates powerful new alliances among them all.

All of these things are possible if our citizens -- teachers, administrators, parents, and business and community leaders -- are prepared with the fortitude and hard work required to take up the challenge of change. Today's vision of the future can be turned into tomorrow's reality if the nation begins with a simple step: It should "smell the future." That future continues to beckon America.

Teachers and administrators report marked improvements in standardized test scores and writing skills, together with significant declines in student absenteeism and transfer out of the school.

Northbrook Middle School
Houston, Texas
Preparing life-long learners for the world of work

Northbrook Middle School is a new creation in an old building. It serves a 6th through 8th grade population of under 800 students. Seventy percent are Latino, and 76 percent are economically disadvantaged. The school had an initial six million dollars for startup, of which one and a half million was devoted to technology.

School administrators understand their main mission to be the preparation of their students as life-long learners for the world of work. The curriculum, while centered on traditional academic subjects, places heavy emphasis on students acquiring critical thinking and problem solving skills. Teachers are expected to assist students in learning how to find and analyze information.

To support this student-centered learning environment, the school is organized into interdisciplinary teams. Teachers and students in each team work together to support one another in continually expanding their ability to gather information and solve problems. Technology is viewed as a primary vehicle to help students develop critical thinking and problem solving skills. Technology permits instruction to be tailored to individual student needs.

Northbrook's technology program is centered primarily on the use of computers. With over 400 computers in the school's six technology labs and 48 classrooms, Northbrook has a student to computer ratio of just under 2:1. Each of the school's classrooms is outfitted with between four and five computers. All of the computers have access to CD-ROM players in order to expand the range of software products available for student use. Access to network resources supports student information searches. Computers in the classrooms, in the computer labs, and in the library are networked together in a school-wide LAN with Internet connectivity. Video technology allows for viewing on three channels. Teachers also make use of multimedia presentation

equipment. Each of the classrooms is outfitted with a videodisc player, a VCR, a cable ready TV, and an overhead projector with a liquid-crystal display panel (LCD). Each team has access to a scanner.

To support the technology program, Northbrook has relied primarily on on-site staff development. Each of the school's 48 original teachers received two weeks of technology-related staff development in the summer prior to the school start-up. On an ongoing basis, teachers have an average of three to four days of paid training each year. Teachers also make a commitment to complete an individualized training program through after-school offerings. Additional personnel to support the technology program include a full-time technology assistant and a district technology coordinator housed on the campus.

Lighthouse Districts and Schools

According to a RAND analysis of several of lighthouse districts and schools, they share several common elements:[1]

- These schools are **learner-centered** -- they emphasize individual treatment of students based on their needs and capabilities.
- Pioneer schools use **curriculum frameworks** to assure that goals for student learning are clearly understood.
- The **density of computers** in most of these schools far exceed the national average.
- School **programs** have been substantially **revamped** -- e.g., longer class periods and interdisciplinary programs are common.
- **The changes in these schools are a result of concentrated, conscious, explicit development and planning.** Most of these schools' efforts have initial increases in funding, often quite substantial.
- **Relations among adults** in the school, and between adults and students appear to change dramatically. More collaboration and consultation result.
- **Schools assess the results** in rich and diverse ways -- traditional test scores along with student attendance and dropout rates,

[1] See Current Use of Telecommunications and Computing Technology in Elementary and Secondary Education. (Washington: The RAND Corporation, Draft, June 1995).

Christopher Columbus Middle School

Union City, N.J.

Technology in support of sweeping educational reform

Technology can connect classrooms and communities with spectacular results. The Christopher Columbus Intermediate School in Union City, N.J. provides an excellent example. Christopher Columbus has successfully integrated up-to-the-minute computer technologies, school curriculum, and a network wiring classrooms to the homes of students, teachers, and administrators. Truancy and dropout rates fell through the floor; test scores went through the roof -- all in an inner-city school system in such dire shape in 1989 that the state threatened to take it over.

Communication inside and outside of school is the purpose of the Interactive Multimedia Education Trial at Christopher Columbus. Union City is the most densely populated city in the U.S. and second only to Miami in its concentration of Latino residents. Since 1992, Bell Atlantic and the Education Development Center, Inc., have worked with the Union City school board to let technology support and enhance the district's sweeping educational reforms.

The technology trial began in September 1993, when all students and teachers in the seventh grade at Christopher Columbus (and student families) were supplied with computers and telecommunication capabilities at home and at school. Each classroom has two Macintosh computers. The computer lab has 35 machines. And the media resource room has four. Through the trial machines, students can access the Lotus Notes network connecting them to the Department of Defense Dependent Schools (DoDDS) and the Internet, as well as a virtual CD-ROM library.

The majority of students use the network to communicate with one another, their teachers, and administrators on a regular basis. While much of the communication is social, they are also using the technology extensively as a tool to collaborate on school projects, to obtain information about missed assignments, and for report writing.

parental engagement, job placement success, and support from students and community.

Taylorsville Elementary School
Taylorsville, Indiana
A Modern Red School House

Taylorsville Elementary School serves more than 600 suburban students in pre-kindergarten through 6th grade. The students are predominantly from lower middle-class, white families.

The school is one of several in Indiana working with the Modern Red School House education design team — a New American School Development Corp. (NASDC) to bring information technology into its educational delivery. Taylorsville's technology plan, hardware layout, and staff development efforts reflect the essentials of the Modern Red School House design. The most important role for technology in the design is to support a commitment to self-paced individualized learning.

The school's curriculum emphasizes core subjects, aiming for high levels of proficiency in language arts, math, science, history and geography. Despite this emphasis on standardization in content, educational delivery focuses on students proceeding through coursework at their own pace. Instructional strategies promote multi-age, multi-year groupings and stress team-based project work. The opportunities for regrouping teams during project work allows individual students to develop their skills in different areas at an appropriate speed. By virtue of their role in integrating instruction across subjects and grades, teachers play a key role in facilitating the transition to a self-paced student environment.

Taylorsville provides students with a great deal of access to networked computers. Taylorsville has one computer lab equipped with 30 Apple computers. Each of the school's 25 classrooms has a cluster of four student computers, one teacher computer, and two printers. Most of the classroom computers have internal CD-ROM drives to increase the range of software applications accessible to students. A school-wide LAN connects classroom computers to the computer lab and to administrative offices. At present, students can access the Internet from two computers in the library media center. Plans provide for Internet connectivity to each classroom. Investing in

the hardware and other infrastructure required to give each classroom Internet connectivity is an outcome of the school's commitment to supporting student project activity. The same principle has led also to outfitting the library with eight IBM clones that use sophisticated software to facilitate information and reference searches.

To support its vision of a self-motivated, self-directed student population, the school invests heavily in staff development. Because teachers are to serve as facilitators for student learning, teacher fluency in using information technology determines the model's success. In the first two years of implementation, staff received six full days of technology training per year. After that, two days a year have been devoted specifically to training in technology. A full-time technology coordinator, with the assistance of three part-time aides, assists teachers with their technology-related problems.

Blackstock Junior High School
Port Hueneme, California
Creating Smart Classrooms

With annual per student expenditures in 1994 of some $4,000 (about two-thirds the national average), this 36-classroom school with 960 students caters to a largely minority population of mostly Hispanic descent, with smaller numbers of Chinese and Vietnamese background. Many students are eligible for Title I support, and 22 percent have limited English-language skill.

Blackstock's model of educational technology delivery centers on creating what are called "smart classrooms." There are at present eight smart classrooms, including two for 7th grade science, one for 8th grade science, two for literature and history, one for ESL, one for business education, and one called the Tech Lab 2000. Each classroom has between 25-30 computers on a local area network (LAN), a sophisticated file server and a SOTA switch to give the teacher maximum control over classroom dynamics. Students can all work on the same project, or there can be a variety of things going on in the classroom at the same time.

The Tech Lab 2000 is perhaps most appropriately described as the futuristic equivalent of a wood or metal shop. Designed to make students familiar with the technology present in the modern workplace, the Tech Lab is outfitted with Computer

Assisted Design (CAD) software, a Computer Numerically Controlled (CNC) flexible manufacturing system, pneumatic equipment, and a satellite dish.

In each of the school's other classrooms, there are banks of ten computers and two printers. Teachers are able to use many software applications, from word processing to interactive programs, in their instruction. They can also draw on the school's connection to the Internet to create a more technologically rich environment.

Staff development efforts for teachers in the smart classrooms have centered on giving individual instructors large amounts of paid time-off to familiarize themselves with technology and to organize a technology-based curriculum. Of the eight teachers in the smart classrooms, four took a year off and one took two years off. The other three teachers were given three weeks during the summer to set up a second smart class in a subject area where one already existed. The presence of a teacher with technological and curricular know-how made it easier for the new teacher to get up and running more quickly. Ongoing staff development for all teachers, is supported by four paid days of technology training per year and a considerable amount of informal networking.

To date, Blackstock has not had a technology coordinator to support staff development efforts, relying instead on paid leave time and informal networking. To keep the technology program running smoothly, there is a teacher who has devoted about a quarter of his time to technology-related problem-solving and to computer repairs. Starting next year this teacher will move into the position of full-time technology coordinator.

East Bakersfield High School
Bakersfield, California
Education to build job-related experience

East Bakersfield High School emphasizes a technology-rich, school-to-work transition program in a school serving 2400 students, with a majority Latino population and an educational philosophy that education equals experience.

The school's administrators aim to have students understand early that their high school education shapes their job prospects, and that their present educational experience is a way of building job-relevant skills. Exposure to business and career-

oriented themes begins immediately in the ninth grade and continues throughout their high school education, and includes resume writing, portfolio building and project activities oriented towards the local business community.

The curriculum is organized around five career "tracks" designed to allow students to develop technical and applied skills related to broad industry groups: science, technology, engineering and manufacturing; health careers; communications and graphic arts; human and government services; and business and entrepreneurship.

Technology-based instruction is integrated smoothly into coursework from beginning to end. As freshmen, students take a nine-week course in keyboarding and basic computer literacy. Writing assignments in the freshman English and history core courses are organized to ensure that all students moving into their sophomore year are proficient in the use of word processing programs. As seniors, students have to complete a technology-based project as a graduation requirement. Projects involve the use of computers, graphics software or video equipment.

General instruction between the first and final years is heavily technology-based. Math classes integrate an interactive math program. English, history and social studies teachers have access to writing labs as well as a large number of video towers equipped with CD-ROM, videodisk players and VCRs. The school building is in the process of being rewired to accommodate network technology. In 1996, many of the classrooms will have Internet connectivity.

There is a limited amount of funding available for paid, formal technology training, but the school has a teacher lab equipped with nine computers and a laser printer. Many of the computers have CD-ROM capabilities. To keep the technology component of the school running smoothly, the school also has a half-time technology coordinator, a full-time repair specialist and a budget for hiring network specialists on an as needed basis.

Computer Club of Green Valley
Sahuarita, Arizona
"The Sahuarita Program has changed my life."

Members of the Computer Club of Green Valley, located in Sahuarita south of Tucson, spend hours every week helping local elementary school children learn how to use and work with computers. There is nothing unusual about community volunteers in schools—but every member of the computer club is retired and most retirees do not dream of spending their time teaching young children complicated new skills. Nonetheless, many of the club's members, often aged 70 and over, say the "Sahuarita Program has changed my life." And many elementary students have this to say about their mentors: "They're wonderful."

It is not too far from the truth to say that the computer club members are largely responsible for equipping and providing 542 students in grades K through 5 with 27 personal computers and four printers. Club members enlisted support in the community and the state for a supermarket Safeway Store receipts program that helped produce computers and software. The school district provides a classroom and one paid coordinator. Club members—there are more than 800 of them—took the initiative to start the volunteer project to create a computer lab and staff it with volunteers.

What do the volunteers teach? Just about everything related to computers. The program provides at least one hour each week for each class in keyboarding, creative writing, spelling, math facts, graphic arts, geography, educational games, and learning how to operate computers. The more expert retirees teach classes at all levels in many different application areas and in computer repair. They also act as mentors during each class, helping students through assignments and offering personal guidance and attention.

The success of a math program called "Math Facts"—highly regarded by both students and teachers—challenged the club to develop similar programs using language, which usually requires more sophisticated software than math tests. A retiree from General Electric developed the "template program" and a course to prepare teachers to write tests that can ask questions and correct answers, score the test, grade the test

(percentile, letter or descriptive grade), and offer the student praise or suggestions for further study.

The club is now addressing the challenge of obtaining higher speed computers and printers. As Principal Nancy Harrington says: "Since we can't add hours to the day, or to our school class schedule, we must speed up our computer system."

Elements of Successful Professional Development for Technology

According to experienced practitioners and researchers, professional development for technology is most likely to succeed if a few basic principles are followed.

- **Integrate technology into the existing curriculum.** This means not making "technology" a separate subject but a means to teach English, mathematics, science, foreign languages, and other subjects.

- **Give teachers adequate time** to acquire new skills and plan for the school's program and activities. Teachers engaged in reform are too often asked to learn new skills on their "own" time. It can take as long as three years for a teacher to become a confident user of technologies.

- **Train teachers in teams of two or more, not as isolated individuals.** Teachers learn with, and from, their colleagues. More than one teacher in a school provides a measure of support.

- **Provide teachers with access to equipment and ongoing support while they learn.** All of the successful technology-intensive schools examined in a recent RAND study had school technology coordinators who were entirely devoted to supporting teachers and staff. Without the equipment, teachers cannot master new tools. Providing equipment that teachers can take home helps.

- **Secure the support of school administrators.** Teachers need support from principals and administrators for learning new skills. Administrators need to give teachers the authority and flexibility to adjust daily instructional schedules, and affirm that teachers' use of technology is important to the entire school.

The Dalton School

New York, N.Y.

"Surfing the Web": Astronomy for Humanities Students

Project Galileo, a course designed at the Dalton School, teaches a full year of college-level "modern astronomy for humanities students," using a Macintosh-based information landscape. The desktop planetarium integrates images from the National Air and Space Administration, the National Oceanic and Atmospheric Administration, working observatories, the Astronomical Data Center, and other sources.

Except for a few homegrown Hypercard reference stacks and one lunar phase program, no specific educational software is used--only general software packages such as image processors, spreadsheets, data base management systems, plotting programs, scanners, and word processors.

While the course uses standard texts and journal articles as references and supplementary reading assignments, students are encouraged to "surf the web" looking for information wherever it can be found. Moreover, as teacher and course designer Malcolm H. Thompson describes it, the "course is a new way of doing business" since the overall objective of using the World Wide Web and encouraging students to publish their results on a home page on the Web "fundamentally shifts the teaching and learning paradigm."

Says Thompson: "What was once a universal standard of a closed, semi-confidential process is now a new, openly public process. This means that course products are now public documents, not private communications. It means that students become public figures. And it means that the public can now look in on the process."

A formal evaluation is not available, but Thompson reports that the quality of student work is high and that "virtually all students have expressed gratitude and appreciation for newly acquired facility with the WWW in the course and for their newly acquired facility with it."

EFFECTIVENESS SIDEBAR

Educational Technology: Does It Work?

The use of technology in schools has had at least three distinct phases. The first, beginning in the 1960s, still carries the name computer assisted instruction (CAI). These activities, motivated by theories of behaviorism and management, emphasized drill-and-practice and basic skills. CAI is still widely used in military training and adult education programs. According to Kulik, major analyses of CAI "have demonstrated repeatedly that programs of computer-based instruction usually have positive effects on student learning."

The second phase of technology use developed as schools acquired modestly priced personal computers (PC) starting in the early 1980s. There were courses in computer literacy and computer programming, especially the popular BASIC language. As the number of PCs in the schools increased, this phase rapidly evolved to incorporate courses in the use of word processing, spreadsheet and database software while sharply reducing the emphasis on programming. The courses are intended to prepare students for using these general-purpose software tools in business and industry. No large research literature on the effectiveness of these activities has emerged or is likely to. The effects are clear in the ability of the students to use the tools.

More recently, the third phase of technology use is driven by the growing number of computers in the classroom, interactive multimedia tools, and electronic networking, especially the Internet and World Wide Web. In addition, the principles of cognitive science argue that students learn and better retain what they learn when engaged in 'authentic' learning tasks. In current school practice, this takes the form of individual or a small group of students carrying out projects using computer and network software tools and databases. While there is little quantitative evidence, there are large numbers of anecdotal reports of successful projects.

It must be emphasized that schools making widespread use of technology support all types of use -- computer assisted drill and practice, the development of computer skills, and the use of technology in group problem solving. The ubiquitous nature of technology use and the variability in that use among students mean that traditional means of assessing the improvement sin a school's performance attributable to technology are not easily applicable. However, school leaders in technology - rich schools measure their progress in a number of ways: improved student attitude and engagement; richer classroom content; better student achievement, measured by norm-standardized tests; improved student retention and job placement rates of secondary school graduates; and increased student enthusiasm for learning, together with an increased student commitment for responsibility for learning. What is clear from experiences of schools

participating in the RAND workshops is that extensive use of technology can produce significant improvements in school performance. This is not the equivalent to saying that extensive use of technology will produce those improvements. As with almost all approaches to education, the effectiveness of technology in support of learning is associated with the quality of its implementation.

Sources: J. D. Fletcher, Institute for Defense Analyses, "Does Instructional Technology Work?" 1995 James A. Kulik, "Meta-Analytic Studies of Findings on Computer-Based Instruction," (*Technology Assessment in Education and Training*, edited by Eva L. Baker & Harold F. O'Neill, Jr.) And RAND workshop on effectiveness of technology, June 1-2, 1995.

Maxwell Middle School

Tucson, Arizona

The Fourth "R": Reading, Writing, Arithmetic, and Ready for the world of work

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Maxwell Middle School in Tucson, Arizona, was considered a "school at risk" in 1990. Its population is 86% minority with 90% of the students on free or reduced lunch, high rates of absenteeism, and large numbers of students who drop out.

During the 1991-92 school, the Maxwell Middle School Computer Classroom Pilot was launched. The first test group included about 120 seventh grade students and a team of four teachers. Each of the four classrooms received 20 personal computers, networked so that students could log on at any worksite. The goal of the program was systemic change that would fully integrate technology into the everyday life of students. Don Collier, principal of Maxwell, said, "We call it the Fourth R. That's Reading, Writing, Arithmetic, and 'Ready for the World of Work.'"

The pilot program was so successful that Maxwell drew the corporate support of Compaq Computers, which agreed to give the school $1.5 million worth of hardware. This allowed complete seventh and eighth grade technology access, curriculum integration, and restructuring for the 1993-94 school year. The 600 students at Maxwell now can access 305 work stations. Twelve classrooms are equipped with 20

personal computers and color monitors integrated with a local area network. A Microsoft NT links the computers to a Compaq Systempro file server, which offers several programs donated by Microsoft.

Maxwell used Title I funds as a base to restructure the school into education teams. Every teacher has two planning periods per day, scheduled so that all members of a team have common planning periods. Daily team meetings are also held to address team issues and curriculum and technology integration.

Maxwell has 60 laptop computers available on a signout basis. The school has found that letting students take their technology home permits families to become excited and involved. Maxwell is working on helping parents communicate via E-mail in both English and Spanish.

Descriptions of the programs described in "Making it Happen" relied on several sources, including the following:

Cost of High Technology Schools by Brent Keltner and Randy Ross. (Washington: RAND, DRR-1066-DoED/CTI, July 1955.)

Blackstock Junior High School
Christopher Columbus Middle School
East Bakersfield High School
Northbrook Middle School
Taylorsville Elementary

Educational Content on the Big Wires: Partnerships Between Developers and the Cable and Telephone Industries. (Washington: Software Publishers Association, 1994.)

Education First, Pacific Telesis

Ingenius, Tele-Communications Inc. (TCI) and Reuters NewsMedia

Schools and Programs Making Time Work for Students. (Washington: National Commission on Time and Learning, 1994.)

The Computer Club

Hefferan Elementary School

Image Processing for Teaching

Learning through Collaborative Visualization

Piscataquis Community High School

Source ???

Maxwell Elementary

Muir Elementary

Pease Middle School

The Galileo Program description was developed from materials provided by the Dalton School.

Pull Quotes for Technology Report

"At Texas Instruments we are doing three times as much business today as we were ten years ago. We have learned how to use technology effectively to enhance all facets of the business."

Business Leader
San Antonio Forum

QUOTE 1

"We need a new idea of 'colleague.' I am getting the idea that my colleagues should be college professors, cable television educators, local PBS education people, local service club members, local business people, state education people, software developers.... These connections should be an essential part of an 'infrastructure.' "

Teacher
On-Line Forum

QUOTE 2

"One thing I like about the computer is that it does give a lot of instruction -- and you don't need to have hearing to take advantage of the instruction."

College Student with a Hearing Disability
Consumer review panel sponsored by U.S. Department of Education

QUOTE 3

"I must say World Wide Web is the best place there is if you want to find information fast and easy. The last major project I began required me to find information on both Antarctica and New Zealand and I found it quickly through Netscape.

Student
On-line Discussion

QUOTE 4

"Public education has never been equal. Technology simply makes that more evident."

Parent in Richmond, Virginia
Focus Group

QUOTE 5

Pull quotes for technology report

"If classes aren't offered on how to use computers and technology to build skills and get jobs, it is a disgrace. Think of the future and all the skills our children will need...."

San Antonio Parent
Regional Forum Participant

QUOTE 6

"Officials really needs to step up to the leadership plate on this. We have to make sure the public understands the stakes involved in getting technology into the schools

Principal
RAND Workshop on Professional Development

QUOTE 7

"I've never found anything that would keep students reading and writing for an entire period until the 'net.... My second-graders just received a letter from a school in New Delhi, India. Guess which country we are now studying?"

Teacher
On-Line Forum

QUOTE 8

"How do I use technology? I use the word processors in the computer lab.... I have an Internet account which I have used to research George Bernard Shaw and the earthquake in Japan. I have used the school scanner to add pictures into projects. The card catalog system is networked between our two libraries.... In my math class, we have a networked system of IBMs.... On a schoolwide basis, computers figure out my schedule for next year, record my absences, and hold my grades and college information."

Student
On-Line Forum

QUOTE 9

"No matter how good the technology is, the money is not well spent if teachers can't translate it into learning."

Parent in Richmond
Focus Group

QUOTE 10

"How many of us have visited schools after passing a technology levy only to find the new computers stacked in boxes in the corner?"

State PTA Leader
Seattle Forum

QUOTE 11

"Our survey indicates that parents are voting with their dollars. Families with modest incomes are making incredible sacrifices to buy computers for their kids."

Marketing Expert
RAND Workshop on Financing Technology

QUOTE 12

"I was in a computer lab in an inner-city high school installing some software. Row on row of gleaming...computers filled the room -- one for each student... There was no sound, no discussions, no little squeals of interest, no outward sign of inner thought. The girl next to me...was learning to type... I asked the teacher; 'Do you ever use computers to teach something besides how to use a computer?' 'What do you mean? ... We couldn't. We haven't got enough computers. We would need more technology. That's our big problem, you know -- we haven't got enough technology.' "

Computer Systems Designer
On-Line Forum

QUOTE 13

"Another problem is that many of the platforms in schools are seriously outdated. We estimate that about 46 percent of DOS machines in schools are incapable of operating Windows. And we also find a lot of old Apple IIs still floating around in schools, long after the rest of the world has forgotten these dinosaurs."

Software Developer
RAND Workshop

QUOTE 14

Pull quotes for technology report

"You can lose money on school software even if you succeed in cornering the entire market! The analogy for textbook publishers would be if they could sell textbooks only to the library."

Software Developer
RAND Workshop

QUOTE 15

"The technology is here. The problem is not with the technology, but with the corporate processes. Companies must fundamentally change the way they do business, and that's hard."

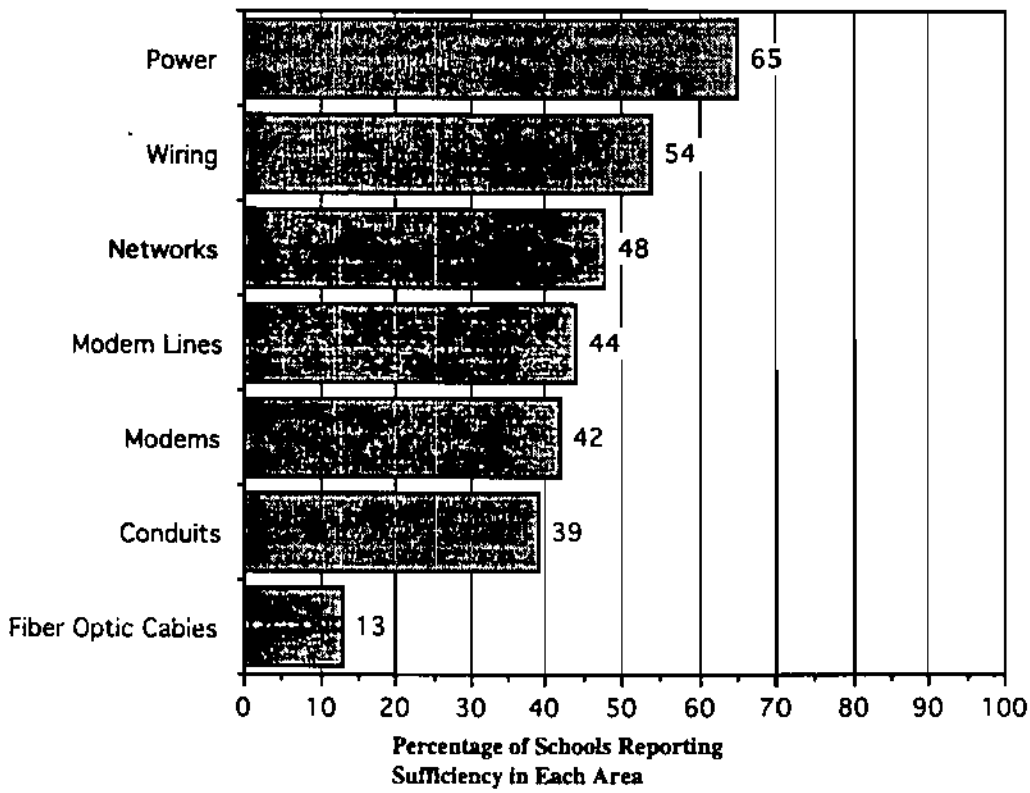
QUOTE 16 *Corporate Executive*

"We have information ghettoes right in the middle of our cities."

San Antonio Parent
Regional Forum Participant

QUOTE 17

Figure 1
Many Schools Lack Infrastructure



Source: U.S. Congress, General Accounting Office: ***School Facilities: America's Schools Not Designed or Equipped for 21st Century, p. 30, 1995***

94-95 Technology Expenditures

Category	Dollars per Student	Pct. of Total
Total Expenditure	82.05	100%
Hardware	47.96	58%
Software	10.47	13%
Supplies	6.24	8%
Training	2.91	4%
Service	4.24	5%
Other	10.23	12%

Figure 2

This should be converted to Pie Chart, & cited appropriately

Quality Education Data, Inc.

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Figure 3
Computer Ownership by Household& Ethnicity, 1995

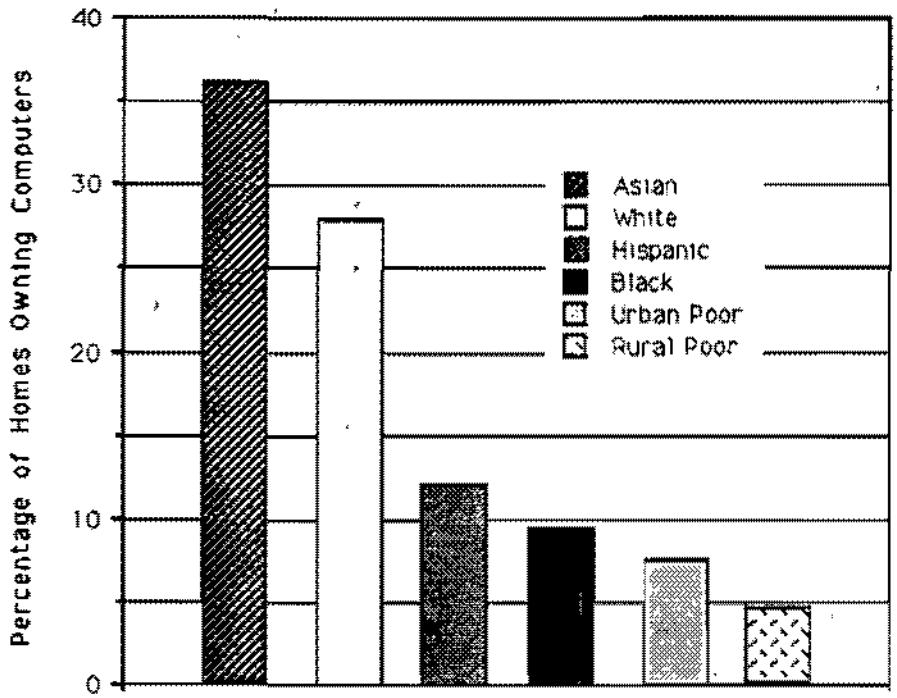
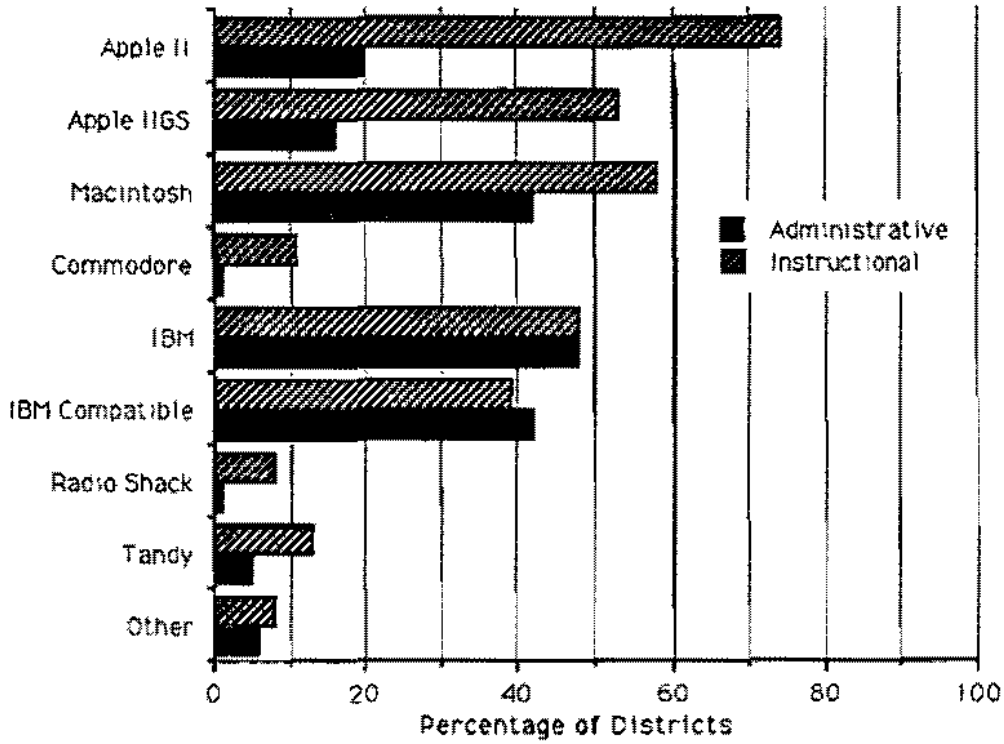


Figure 4
District Use of Personal Computers by Brand and Purpose



Appendices

A. Glossary

B. Acknowledgments

C. Participants in Development of Plan

D. Resources/Bibliography

Appendix A
Glossary

In developing this glossary, the following sources were very helpful:

Jones Cable Television and Information Infrastructure Dictionary, Fourth Edition, published by Jones Interactive, Inc.

Arthur Melmed, A Learning Infrastructure for All Americans. (Working Paper #93.6 of the Institute of Public Policy, George Mason University, Fairfax, Va.) June 1993.

Access channels Dedicated channels giving nondiscriminatory access to the cable system by the public, government agencies, or educational institutions.

Addressability In cable television, the ability of cable operators to remotely activate, disconnect, or selectively descramble specific television signals in individual subscriber's premises; often associated with pay-per-view (PPV) services.

Addressable controller A cable converter box that, in addition to offering conventional channel selection, is individually addressable by headend systems. Used in customer-by-customer pay-per-view interactions, movie selections, and other interactive customer-by-customer services. Also known as addressable converter.

Advanced Research Project Agency (ARPA) An agency of the U.S. Department of Defense that developed the ARPAnet.

Advanced technology. Refers to computer networks, such as the Internet and the future National Information Infrastructure (NII), or "Information Superhighway"; interactive video connections for distance learning; software tools and programs such as multimedia, simulations, and spreadsheets; and local, remote, and distributed digital storage technologies such as CD-ROMs and electronic libraries.

Affiliates A cable television system that carries specific programming. For example, a cable system that carries programming from C-SPAN, Mind Extension University and ESPN is considered an affiliate of each of those cable programming services.

ARPAnet A wide-area network project financed by ARPA that developed packet switching as a technique for ensuring continued digital communications in event of failure of individual telephone circuits. A testbed initiated in 1969 grew to link many universities, research and defense establishments in the US. In 1983, military computer-communications was split off into MILnet. The remainder developed into the Internet.

Associated broadcasting station The broadcasting station with which a remote pickup broadcast base or mobile station is licensed as an auxiliary and with which it is principally used.

Asymmetrical digital subscriber line (ADSL) A method in which phone companies use existing twisted-pair copper wires to deliver VHS-quality video signals and other high-bandwidth signals in one direction (from service providers to customers) while using the same wires to support low data rates and/or analog voice transmissions in other directions (from customers to service providers). Video on demand is a proposed application for ADSL service.

Asynchronous transfer mode (ATM) A proposed communications standard for the emerging broadband digital network in which text, audio and video data are fragmented into fixed-sized cells for transmission to their destination using packet switching.

Audiotex An information service that gives customers access to prerecorded messages, including weather reports, sports scores, astrology predictions, inspirational messages, X-rated messages, and jokes. National audiotex services often use a 900 number, whereas local services commonly use 976 numbers.

Aural cable Services providing FM-only original programming to cable systems on a lease basis.

Average picture level (APL) The average level of the picture signal during active scanning time integrated over a frame period and expressed as a percentage of the blanking to reference white range.

Backbone The backbone is the part of the digital communications network that carries the heaviest traffic. It can link LANs within the same building or WANs distributed around the country. In the special case of the Internet, the backbone is NSFnet.

Bandwidth or Bandpass Roughly, a measure of the electronic size of the pipe, or the amount of digital data that can be passed by the circuit.

Bandwidth on demand (BOD) The ability of a customer to adjust or change the bandwidth of the connection to and from a network provider. Fractional DS-1 service, frame relay, asynchronous transfer mode (ATM), and bandwidth on cable have the potential to be BOD platforms.

Basic service element (BSE) In the public switched telephone network (PSTN), a local-exchange access function, interface, and service capability that Bell operating companies must provide, on a non-discriminatory basis, as dictated by the Federal Communications Commission's Computer Inquiry III (open network architecture) proceedings. The purpose of basic service element requirements is to ensure equal access for non-Bell vendors of enhanced services.

Baud A measure of circuit bandpass, the rate at which symbols can be transmitted independent of the number of bits used to encode the symbol.

Bell operating company (BOC) In telephony, one of the 22 regulated local-exchange carriers divested from the AT&T Bell telephone system by the Modification of Final Judgment (MFJ) in 1984. The 22 companies are organized into subsidiaries of the 7 regional holding companies (RHCs). RHCs are also called regional Bell operating companies (RBOCs).

Books-on-demand Network service that uses advanced electronic publishing technologies, including high speed printer/binders, to produce a book within minutes of a request.

Bridge Software and hardware needed to link LANs with different network architectures to a backbone.

Broadband Any system able to deliver multiple channels and/or services to their users or subscribers. Generally refers to cable television systems. Sometimes called wideband.

Broadband communication Term characterizing both digital and analog transmission systems. If used to describe digital systems, transmission speed is given in bits per second (bps). If used to describe analog systems, transmission bandwidth is given in cycles per second (Hertz, abbreviated Hz). Broadband communication is generally understood to indicate either a fast data rate digital system or wide bandwidth analog system.

Cable television A broadband communications technology in which multiple television channels as well as audio and data signals are transmitted either one way or bidirectionally through a distribution system to single or multiple specified locations. The term also encompasses the associated and evolving programming and information resources developed locally, regionally, and nationally.

Cable television system (CATV) A broadband communications system capable of delivering multiple channels of entertainment programming and non-entertainment information from a set of centralized satellite and off-air antennas, generally by coaxial cable, to a community. Many cable television designs integrate fiber-optic and microwave links into their overall design.

Carrier (1) An electromagnetic wave of which some characteristic is varied in order to convey information. (2) A company such as the local telephone company or a long-distance provider that provides communications circuits.

Channel A signal path of specified bandwidth for conveying information.

Circuit switching The operating mode of the telephone network and some digital data networks in which an exclusive communications path is established and used between the connected terminals for the duration of the connection.

Client-server Mode An operating mode of computer-communication networks in which a (server) file storage system responds to requests of a (client) user program.

Coaxial cable A transmission medium consisting of a center conductor and a concentric outer conductor used when high data rates are required, e.g., television.

Communication channel A medium by which analog information or digital data can be transmitted, for example, copper twister-pair wire, microwave radio, or optical fiber. Transmission rates vary according to the type of communication channel used: copper twisted-pair wire can transmit analog voice at a bandwidth of 3 kHz or digital data at 300 to 9,600 bps and higher, coaxial cable at 1 to 2 Gbps and higher, microwave radio at 1 to 140 GBs and higher, and optical fiber at 1 to 1000 Gbps and higher.

Competitive access provider (CAP) A carrier-like telecommunications company, often unregulated, that provides an alternative to the local exchange carrier (LEC) service for large businesses. Formerly, CAPs installed fiber rings and only provided unswitched bulk transport within major U.S. cities. Today, some CAPs are adding switches to provide switched services and are buying interconnection circuits to other CAPs, interexchange carriers (IXCs), and cable television systems. Also known as alternative access provider.

CompuServe One of the nation's largest turnkey information resources providing information services on demand, including news, stock quotations, and airline schedules; as well as electronic forums and Email.

Data compression and decompression standards The encoding of data in more compact form in which redundancies are removed in order to save storage space or transmission time. On retrieval or reception, the transformed data are decompressed to the original format. No information is lost in the process.

Direct broadcast satellite A satellite service of one or more entertainment or information program channels that can be received directly using an antenna on the subscriber's premises.

Ethernet The name of a widely used local area network (LAN) developed by Palo Alto Research Center of the Xerox Corporation.

Fiber optics The technology of guiding and projecting light for use as a communications medium. Hair-thin glass fibers that allow light beams to be bent and reflected with low levels of loss and interference are known as "glass optical wave guides" or simply "optical fibers."

File server Typically a computer with large-capacity hard disk and data management software, which delivers files on demand to any terminal device on the communications network.

File transfer protocol (FTP) The application protocol in the TCP/IP suite that provides access to a networked file server.

Gopher A network protocol operating in the client-serve mode that makes available hierarchical collections of information distributed across the Internet.

Headend The control center of a cable television system, where incoming signals are amplified, converted, processed, and combined into a common cable along with any origination cable-casting for transmission to subscribers. System usually includes antennas, preamplifiers, frequency converters, demodulators, modulators, processors, and other related equipment.

HDTV or high definition TV A new TV standard that aims to improve picture quality by doubling the current screen resolution.

ISDN or Integrated Services Digital Network A new worldwide digital telecommunications standard that supports both voice and data communications.

Interactive television Two-way communications using a television as the display. Uses include entertainment, information retrieval, education, and shopping.

Internet A collection of interconnected networks, publicly and privately financed, based on the TCP/IP protocol suite.

Internet protocol (IP) The basis for forwarding data packets among dissimilar networks to their destination address.

Leased line service A line leased from the telephone company for exclusive private use. As opposed to switched lines, leased lines can be specially conditioned to optimize their use for data transmission.

Local area network (LAN) A data communications system used to interconnect a community of digital devices, usually located within a single building or a localized

group of buildings. The devices may be PCs, workstations, minicomputers, "intelligent" instrumentation, etc.

Local loop The connection between the customer's location and the telephone company's central office.

Modem Device used to transmit and receive digitally encoded data on an analog telephone circuit network.

Multimedia conference service A multipoint conversational service providing two or more geographically separated users or groups of users with the capability for exchanging any type of information: text, audio and video images.

Multimedia information A database of files consisting of integrated text, audio and video data.

Narrowcasting Transmission of information by electromagnetic means, intended for a particularly identified audience (for example, industrial television, special-audience cable television, and business and professional programming).

Packet-switched network A network consisting of a series of interconnected (computer) switches that route individual packets of data on a contingent basis over one of several redundant routes.

Protocol A formal description of data formats and rules that two computers must follow in order to exchange messages successfully.

Router Hardware and software used to connect two LANs that have the same network architecture (as opposed to a Bridge).

Simple Network Management Protocol (SNM) The network management architecture for the TCP/IP digital communication protocols, the de facto worldwide network standard.

T1 line A circuit with bandwidth of 1,544 megabits/second.

T3 line A circuit with bandwidth of 44,746 megabits/second. The backbone of the Internet, financed by NSF, recently replaced T1 lines with T3 lines.

TCP/IP (Transmission Control Protocol/Internet Protocol) Set of communication protocols developed with ARPA support to connect dissimilar networks.

TELNET The application protocol in the TCP/IP suite that enables a user at a terminal to interact with a program running on another (often remote) computer.

Two-way cable In cable television, a distribution system that has been designed to support normal "downstream" transmissions (from the cable headend to customers, as well as "upstream" transmission (from customer locations to the headend). Two way cable has been implemented in three different ways: reverse channel activation in existing systems, passive distribution, and dual cable systems. Two-way cable systems are not necessarily interactive cable systems.

Video dialtone A residential and business video service in which customers can dial up others (much like today's telephone service) and through which customers can order video-on-demand and other video-based services.

WAIS (Wide-Area Information Services) A network protocol for remote information retrieval which operates in the client-server mode.

Wide Area Network (WAN) A general term used to describe a network, private or public, that covers a wide geographical area.

Appendix B
Acknowledgments

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Appendix D
Resources/Bibliography

Center for Technology in Learning. *Year 2005: Using Technology to Build Communities of Understanding*. A Report to the U.S. Congressional Office of Technology Assessment. Menlo Park, CA: SRI International, November 1994.

Committee for Economic Development. *Connecting Schools to a Changing World: A Technology Strategy for Improving Mathematics and Science Education*. September 1995.

Council of Chief State School Officers. *U.S. Education and Instruction Through Telecommunications: Distance Learning for All Learners*. Washington, DC: 1995.

Council on Competitiveness. *Breaking the Barriers to the National Information Infrastructure: A Conference Report*. Washington, DC: December 1994.

Education Development Center, Inc. *1993-94 Summary Report: Union City Interactive Multimedia Education Trial*. New York, NY: 1995.

Federation of American Research Networks, Inc. and Consortium for School Networking. *Building Consensus/Building Models: A Networking Strategy for Change*. March 1994.

Gore, A., and Brown, R. *The Global Information Infrastructure: Agenda for Cooperation*. Washington, DC: U.S. Government Printing Office, January 1995.

Harvey, J., ed. *The Market for Educational Software*. Washington, DC: RAND, May 1995.

Harvey, J., ed. *Planning and Financing Education Technology*. Washington, DC: RAND, March 1995.

Harvey, J., and Purnell, S., eds. *Technology and Teacher Professional Development*. Washington, DC: RAND, March 1995.

Information Infrastructure Task Force, Committee on Applications and Technology. *Putting the Information Infrastructure to Work*: Report of the Information Infrastructure Task Force Committee on Applications and Technology. U.S. Department of Commerce: U.S. Government Printing Office, May 1994.

Information Infrastructure Task Force, Committee on Applications and Technology. *The National Information Infrastructure: Reaching Society's Goals*. U.S. Department of Commerce: U.S. Government Printing Office, September 1994.

Interactive Educational Systems Design. *Report on the Effectiveness of Technology in Schools, 1990-1994*. New York, NY: Software Publishers Association, 1995.

Jones, B. F.,Valdez, G., Nowakowski, J., and Rasmussen, C. *Plugging In: Choosing and Using Educational Technology*. Washington, DC: Council for Educational Development and Research, 1995.

Jones, B. F., Valdez, G., Nowakowski, J., and Rasmussen, C. *Designing Learning and Technology for Educational Reform.* Oak Brook, IL: North Central Regional Educational Laboratory, 1994.

Keltner, B., and Ross, R. *The Cost of High Technology Schools.* Washington, DC: RAND, March 1995.

McKnight, L., and Neil, S. *Connectivity and Interoperability for Education through Information Infrastructure.* Washington, DC: RAND, March 1995.

Means, B., ed. *Technology and Education Reform: The Reality Behind the Promise.* San Francisco: Jossey-Bass, 1994.

Melmed Arthur, *A Learning Infrastructure for All Americans.* (Working Paper #93.6 of the Institute of Public Policy, George Mason University, Fairfax, Va.) June 1993.

Merrill, D. *Evaluation of Educational Technology: What Do We Know, and What Can We Know?* Washington, DC: RAND, May 1995.

National Center for Education Statistics. *Advanced Telecommunications in U.S. Public Schools, K-12.* U.S. Department of Education: U.S. Government Printing Office, February 1995.

National Commission on Excellence in Education. *A Nation At Risk: The Imperative for Education Reform.* Washington, DC: U.S. Government Printing Office, April 1983.

National Coordinating Committee on Technology in Education and Training. *The National Information Infrastructure: Requirements for Education and Training.* Alexandria, VA: March 1994.

National Information Infrastructure Advisory Council. *Common Ground: Fundamental Principles for the National Information Infrastructure.* U.S. Department of Commerce, March 1995.

National Science and Technology Council, Committee on Education and Training. *Strategic Planning Document.* Washington, DC: March 1995.

National Science and Technology Council, Committee on Information and Communications. Strategic Planning Document. Washington, DC: March 1995.

Office of Educational Technology. *Making it Happen: Report of the Secretary's Conference on Educational Technology.* U.S. Department of Education, 1995.

Office of Educational Research and Improvement. *Using Technology to Support Education Reform.* U.S. Department of Education, September 1993.

Office of Technology Assessment, U.S. Congress. *Adult Literacy and New Technologies: Tools for a Lifetime.* Washington, DC: U.S. Government Printing Office, 1994.

Office of Technology Assessment, U.S. Congress. *Teachers & Technology: Making the Connection.* Washington, DC: U.S. Government Printing Office, 1995.

Quality Education Data, Inc. *District Administrators Report on the Effectiveness of Technology in the Nation's Schools*. Stamford, CT: Curriculum Administrator, May 1995

Quality Education Data, Inc. *Educational Technology Trends: QED's 7th Annual Sample Survey of Technology Use & Purchase Plans in U.S. Public Schools*. Denver, CO: 1995.

Quality Education Data, Inc. *Networks Now, 1995: Survey of How States Use Telecommunication Networks in Education* (Second ed.). Denver, CO: 1995.

Quality Education Data, Inc. *Technology in Public Schools, 1993-94: QED's 13th Annual Census Study of Public School Technology Use*. Denver, CO: 1995.

Rothstein, R. *Connecting K-12 Schools to the NII: A Preliminary Assessment of Technology Models and their Associated Costs* (working paper). U.S. Department of Education, August 1994.

Secretary's Commission on Achieving Necessary Skills. *Learning a Living*. U.S. Department of Labor, July 1992.

Secretary's Commission on Achieving Necessary Skills (SCANS). *What Work Requires of Schools: A SCANS Report for AMERICA 2000*. U.S. Department of Labor, June 1991.

Software Publishers Association. *Educational Content on the Big Wires: Partnerships Between Developers and the Cable and Telephone Industries*. Washington, DC: 1994.

Software Publishers Association. *SPA K-12 Education Market Report*. Washington, DC: July 1994.

Southwest Educational Development Laboratory. *Networks for Goals 2000 Reform: Bringing the Internet to K-12 Schools*, July 25-September 30, 1994. Austin, TX: 1995.

Stone-Martin, M., and Breeden, L., ed. *Fifty-one Reasons: How We Use the Internet and What It Says About the Information Superhighway*. Lexington, MA: Federation of American Research Networks, 1994.

The Widmeyer Group, Inc. *Report on Technology and Education Focus Groups*. Washington, DC: July 1995.