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File - Old Testing 2 pager

CLINTON LIBRARY PHOTOCOPY

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Connecting Classrooms, Computers, & Communities:

A Strategic Plan for Education

U.S. Department of Education

Connecting Classrooms, Computers, & Communities:
A Strategic Plan for Education Technology

United States Department of Education

Richard W. Riley
Secretary

Madeleine M. Kunin
Deputy Secretary

Marshall S. Smith
Under Secretary

Linda G. Roberts
Director, Office of Educational Technology

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Preface

As the 1990's 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, such as free or inexpensive usage of telecommunications lines, 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 teachers, administrators, students, parents, 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. 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.e.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 have 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 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 49 million students and 2.5 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 reform from the bottom-up.

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 the kind of quality education for every student 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 possibilities in greater detail, and acknowledges, quite candidly, a set of challenges that the nation must meet if technological possibilities 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 possibilities 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.

That is to say, 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 at once, 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 55.7 million students in public and private schools -- seven million more than we have today. A growing proportion of these young people will be Latino and Hispanic, African American, or new immigrants, many of them low-income and traditionally poorly 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

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 (ISLs) have produced some spectacular results for low-income children in compensatory (Title I) programs. The same technologies used to train pilots are being used experimentally to teach orthopedically impaired children, most with

cerebral palsy, how to operate motorized wheelchairs and negotiate the obstacles they might find in a typical classroom or busy street.

It is no secret that a young person who gets 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 new students -- particularly low-income students -- continuing to give them a watered-down curriculum and linking 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

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 education technology will provide handsome, long-term, economic returns, and that the costs will be returned to all of us, many times over, in the form of lower public assistance costs 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. The central place of the private sector in technological evolution demands respect. In brief, a strategy *for the nation* cannot be imposed by the Federal government. How do we get from here to there? 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 education 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.

That is to say, schools should firmly commit themselves to technology as the wave of the future. Nothing will more quickly defeat the effort to improve learning and school use of 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 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 firms in the private sector -- are already saddled with badly out-of-date equipment. In this context, schools need to be flexible enough to stay abreast of change, not 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 school 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, i.e. developing teachers' professional skills with these new tools. One of the most striking findings to emerge in the Department's review of developments in technology is the following: when it comes to technology, the private sector spends three times as much on training as do the nation's schools.

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 possibilities 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 possibilities, 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 education 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 their digital brethren, the facsimile machine and the mobile telephone. Low-cost, high-quality versions of each of these are easily within financial reach of most 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.

CONCLUSIONS

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.

Several analyses indicate that, properly employed, implemented and supported, technology leads to superior learning.[4] The sidebar on the following pages summarizes 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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[4] See, for example Barbara Means (ed.), *Technology and Education Reform: The Reality Behind the Promise*. San Francisco: Jossey Basss, 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 it itself, and it has almost endless 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 Communicate with experts Word processing and spreadsheets Simulations to visualize mathematical and scientific concepts
Group Learning	E-mail supporting group communication Presentation software to encourage group collaboration Video presentations Communications between classrooms encouraging collaboration on projects
Instructional Management	Integrate curriculum standards, and assessments Manage student portfolios and exhibitions Develop student instructional plans and contracts
Communications	With remote locations (e.g., rural schools) to expand access to expertise and resources With parents, students, home and community
Administration	Support for 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.

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.

A new phase has recently appeared, motivated, perhaps, by the growing number of classroom (as opposed to laboratory) computers; developments in local area and wide area networks (LANs and WANs respectively), especially the Internet and World Wide Web (WWW) service; and the principles of cognitive science over behaviorism. These principles 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's not easy to assess the impact of technology on improvements in a school's performance using traditional means. 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.

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 individual learning styles. Students differ. Some like to memorize facts and figures and feed them back to the teacher during testing situations. Others prefer to deal with concepts and the structures underlying them, openly speculating about a variety of possibilities. Some are driven to solve problems, while their neighbors prefer to wander through them, reaching a solution by, in part, solving sub-difficulties along the route. No respectable learning theorist argues that one of these styles is preferable to the others. Emerging technologies can adapt to any and all of them.

New technologies are essential to the success of the current effort to create better schools.

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 joined 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.

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 120-150 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 the unparalleled increase in viewing choices they provide 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 student; but by 1995, the average school had one computer for every 12 students.[5] 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 (about 50 percent of all schools), 39 percent in secondary schools (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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[5] Presentation to Senate education subcommittee, April 4, 1995 by Quality Education Data, Inc. (QED). See also, *QED, Technology in Public Schools. QED's 13th Annual Census Study of Public School Technology.*

[6] QED..

[7] QED.

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).[8] 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, 1994

In sum, the school technology glass is half-full. Considerable 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 considerable 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 students (or fewer), a density that advocates of school technology consider to be minimally adequate.

Other Technologies

Information on other technologies is more fragmented and hard to locate. Data from a 1994 survey are presented in Table 3 below. What is apparent from this

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

information is that most of the technologies surveyed, with the exception of cable television, are available in less than one third of all schools, often less than one quarter.

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 1995 *Survey of Advanced Telecommunications in U.S. Public Schools, K-12,* completed by the National Center for Education Statistics[9] 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 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 Internet than schools with larger enrollments; and
- only about one-half of schools have access to Internet or another wide area network (WAN) and in these schools teachers are seven times

[9] National Center for Education Statistics, *Advanced Telecommunications in U.S. Public Schools, K-12.* Washington: U.S. Department of Education, February 1995.

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 holes 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 GAO survey on the adequacy of the infrastructure (modems, wiring, and the like) in place to support technology.

The results are fairly clear. More than half of all schools report that they now have adequate power and wiring to handle their technology needs. But 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 comparable enterprise.

Figure 2 shows the current school spending mix on technology.

Figure 2 Here

Focus groups conducted as part of this report reinforcethis. 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 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 education technology policy and among them are the following:

- Technology is far more than just another fad; its availability (or lack) 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, the need to rethink organization and processes.

Technology is far more than just another fad; its availability (or lack) 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 a key determinants of student performance. Without conscious attention to this issue, the growing power of technology seems destined to maintain, 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 hard to come by. 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 annual *amortized* technology-costs ranged from $141 to $490 per student.[10] The smallest of these schools enrolls 310 students; the largest, 1,800.

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[10] 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.

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, therefore, the RAND analysis used each school's current equipment inventory and adopted the following cost elements: current prices for all computer hardware; hardware and software prices amortized over five years; special infrastructure such as furniture and cabling amortized over ten years; initial teacher preparation amortized over five years; and costs of new 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 & Technology Support	94,300	37
Materials	10,000	4
Weighted Per-Pupil Cost	$274	100%

Table 5, below, compares with current spending levels the costs of four different national scenarios for increased technology spending. (Current spending on technology is estimated by RAND to be perhaps $3 billion annually, or 1.3 percent of current expenditures devoted to education in the 1994-95 school year.)

The "low alternative" assumes annual per-student spending of $180 -- near the low end of RAND's sample of eight technology-rich schools. The "variable alternative" assumes that all schools below the national average of one computer for every 12 students is brought up to that average and that about 10 percent of all students will attend schools flush with the latest and most up-to-date technologies, i.e., spending at the upper bounds of the eight schools studied by RAND, about $500 per student. The "middle option ' calls for spending $274 per student (the weighted, annual per-pupil expense across RAND's eight schools) on all students. Finally, the high-fixed 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	1.25%	$3.0 billion
Low	$180	3.0%	$7.5 billion
Variable	$125-$500	3.6%	$9.1
Middle	$274	4.5%	$11.2
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 and the variable alternative seem achievable. They call for increasing technology expenditures to about 3.0 to 3.5 percent of all school spending -- a range of spending within reach if current increases in education 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. 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.

The middle fixed alternative (calling for 4.5 percent of expenditures) might even be within reach if several things fall into place. Existing expenditures supporting teacher pay increases for additional education might easily be conditioned on completing courses in technology and its uses. As new schools are built to accommodate burgeoning enrollments in some communities, wiring and infrastructure needs can be built into school plans. And schools can certainly find some of the money required in modest restructuring of school programs and staff, including administrative staff.

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

Diversity and Variability. The computers in America's schools are very diverse. Many of them, in technical terms, are also very old, 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.

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, 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.[11] 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

[11] *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."

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 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, information, and test and sharpen skills, wherever and wherever 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 into the community and beyond the school walls.

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 met, the transformation will come about not by happenstance, but through the development of 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 education 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 instincts, 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 Financing Technology and Wiring 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." (Networks Now 1995)

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 15% discount. In **Texas**, telecommunications services for distance learning must be provided at rates 25% below the normal charges. (Benton report)

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 both formula and competitive grants to school districts. (Varn report)

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 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, $80 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. (OET files; OTA p. 123)

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. (Varn report)

Colorado, Georgia, Illinois, Indiana, Massachusetts, 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 funds are administered by school districts. (Varn report; Benton report p. 23)

The **Idaho** legislature appropriated $14 million for 1995-96 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. (Networks Now 1995)

Florida has increased appropriations for school technology from $36 million in 1993 to $134.7 million in 1994 and $127.9 million in 1995. (Benton report)

At the local level, also, an impressive array of activities is underway.[12] For example, the Central Kitsap Schools of Silverdale, Washington initiated a 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 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 -- 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.

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[12] See report on RAND workshop, *Planning and Financing Education Technology*. Washington, DC: March 1995. "Making it Happen" provides additional examples of similar schools and programs.

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 theory. 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 revolve 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.[13]

[13] For additional detail on these three strategies, see Appendix E.

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.

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 to reach the other 90 percent?

Institutions of higher education represent a first line of attack. Each year, more than 180,000 men and women in the United States receive an undergraduate or graduate degree in education. Over five years, nearly one million teachers can receive the

professional development opportunities they need if technology is infused into the curriculum of schools of education.

States can also play an enormous role in encouraging professional development, and many do. Florida requires districts applying for state technology funds to set aside 30 percent of their awards for training. The state of Washington spends about 40 percent of its technology budget on teacher training. Eighteen states require training in computers or technology for all teachers seeking certification, a 50 percent increase since 1987.

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.

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 free, or 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. A much sounder strategy is one that calls for intensive investment in a few schools or areas initially, building on their success 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 consciously 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 experience implementing new technologies, they can expand the number of schools involved while building into budgets 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 (disadvantaged, limited ability to speak English, 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.

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 partnerships with software developers to get what the states 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:

- **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 most of this research was supported by the Federal government, some firms -- such as Apple Computer Inc. -- have also supported 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 education 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 an array of schools (public and private), colleges, firms, and individuals, which 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 policy 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 Ordnance provided for public schools on the frontier.

That tradition encompasses advocacy and leadership in school reform; the development and dissemination of better information; establishing assistance organizations; and supporting research and development. Thus 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 center 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 the Departments of Defense or Labor -- 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, 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.

Technical Assistance for Financing. In the long run, there is little doubt that public officials and educators can find the funds they need to move forward with school technologies. In the short run, difficulties will inevitably present themselves.

In its leadership role, 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 can examine how states and school districts finance investments in technology and provide advice, counsel, and technical assistance on financing to a broad array of states and districts. The Department's labs and centers are one potential candidate to play this role, but a better set of candidates can be found in the six Regional Technology Consortia (RTC's) established in the fall of 1995. These centers provide technical assistance on financing across the nation.

Telecommunications Policies. The Federal Communications Commission and the Department of Commerce have worked 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 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, a series of workshops

entitled A Forum on Education Software, involving state and local educators, publishers, software developers, on-line services, cable and wireless, operators, and other commercial providers of educational materials and "edutainment." The purpose? To bring together two 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. Finally, 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 already developed and published by the White House National Science and Technology Council. 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 using technology, and dissemination of information.

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 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 patience, 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.

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."

QUOTE 1

Business Leader
San Antonio Forum

"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.' "

QUOTE 2

Teacher
On-Line Forum

"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."

QUOTE 3

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

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"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.

QUOTE 4

Student
On-line Discussion

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

QUOTE 5

Parent in Richmond, Virginia
Focus Group

"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

Pull quotes for technology report

"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

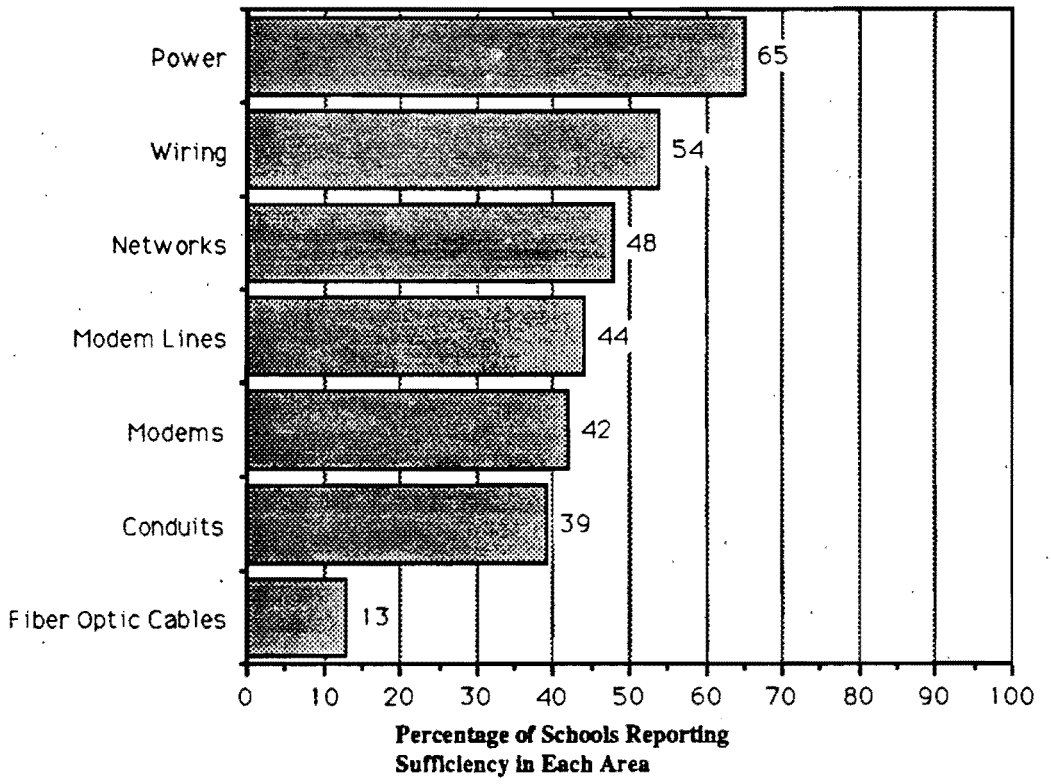
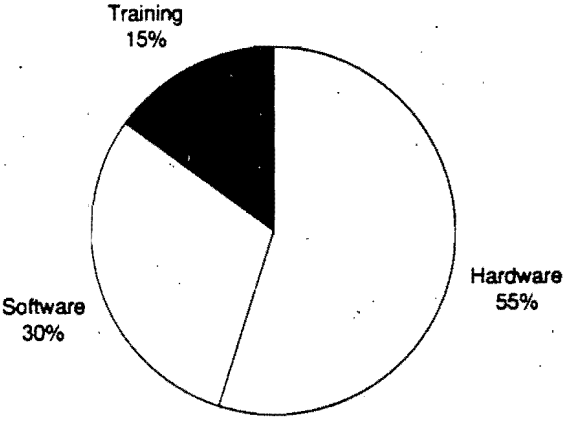


Figure 2
Distribution of Technology Spending



NOTE: District Computer/Technology coordinators were asked to estimate the amount of their total computer budgets spent in the above three categories. N = 3,927.

SOURCE: Market Data Retrieval, *Education and Technology, 1993: A Survey of the K-12 Market* (Shelton, CT: 1993), p. 11.

Figure 3
Computer Ownership by Household& Ethnicity, 1995

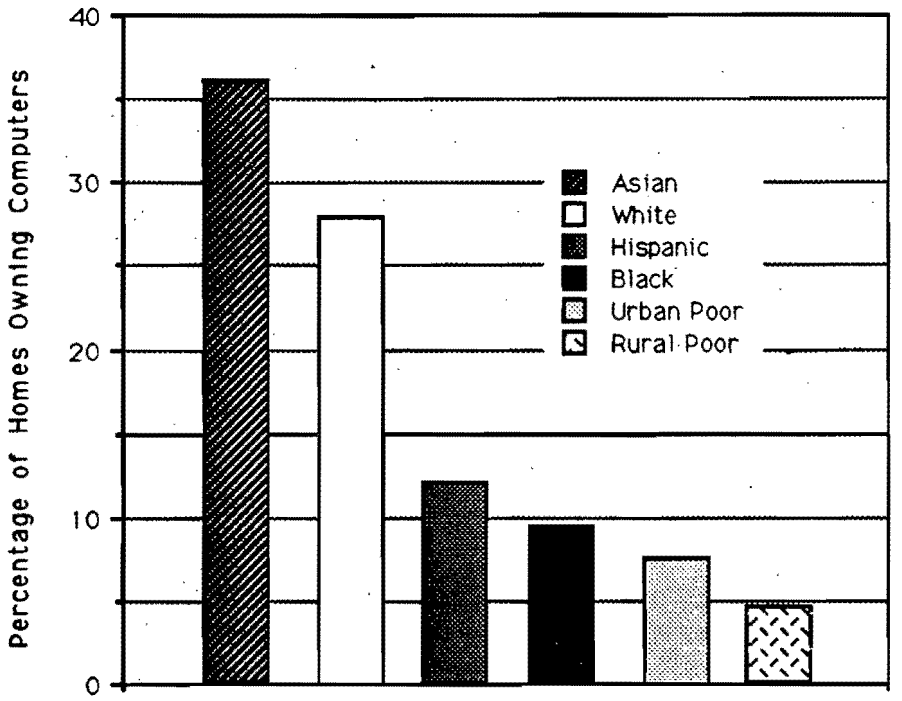
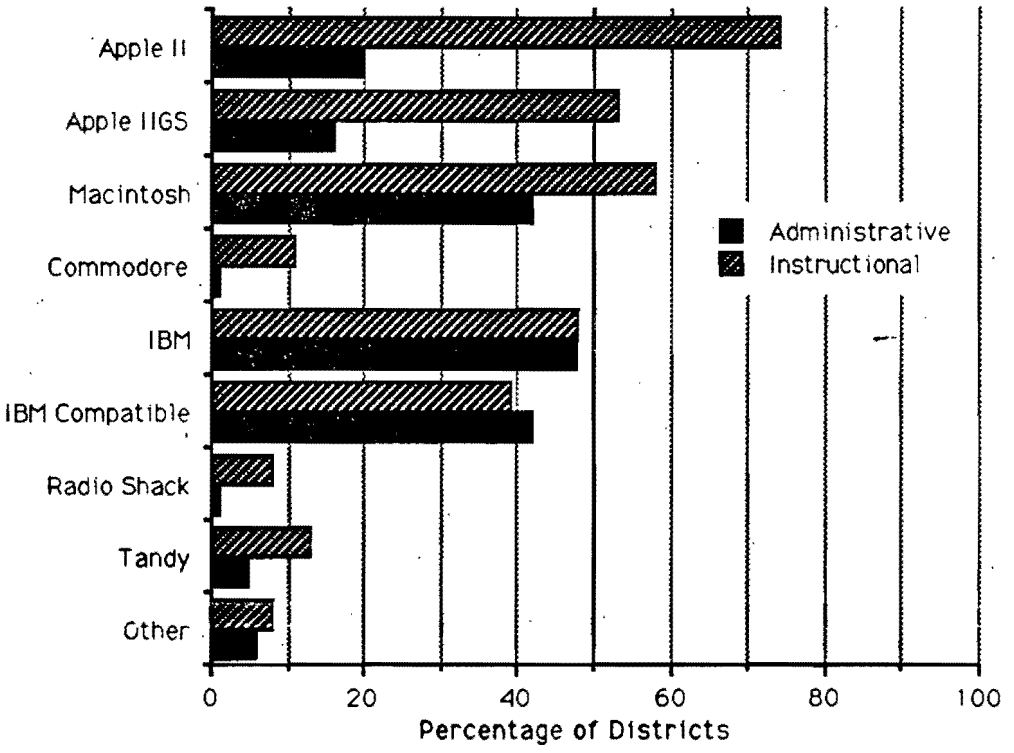


Figure 4
District Use of Personal Computers by Brand and Purpose



Appendices

A. Glossary

B. Acknowledgments

C. Participants in Development of Plan

D. Resources/Bibliography

E. Elements of Strategic Plan

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' 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 US 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 and alternative to the local exchange carrier (LEC) service for large businesses. Formerly, CAPs installed fiber rings and only provided unswitched bulk transport within major US 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

Assistance from many individuals and organizations were essential to the development of this technology plan.

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Appendix C
Participants in Developing Plan
Participants in Developmen of Action Plan

Workshop on Professional Development

Karen Billings, Microsoft Corporation, WA
Jinny Goldstein, PBS, VA
Nancy Hechinger, The Edison Project, NY
Ann Lieberman, Teachers College, NY
Susan Mernit, Scholastic, Inc., NY
Lydia Wells Sledge, Kentucky Department of Education
Mark Steinberger, New York City Community School District 4
Barbara Yentzer, National Education Association, DC

Workshop on Educational Software Market

Bob Dixon, National Center to Improve the Tools of Educators, WA
Bob Dixon, Find/SVP, CA
Thomas Haver, William K Bradford Publishing, MA
Alan Lesgold, University of Pittsburgh, PA
Tom Miller, Find/SVP, NY
Bruce Nelson, Novell, Inc., UT
Randy Pennington, Chancery Software Inc.,WA
Roger Rogalin, Association of American Publishers, NY
Marilyn Rosenblum, Broderbund Software, GA
Jim Schnitz, EduQuest, GA
William Spencer, Simon & Schuster, MA

Workshop on Planning and Financing School Technology and Connectivity

Sue Collins, Apple Computer, OR
Michael Eason, Florida Department of Education
Wayne Fisher, Nebraska Department of Education
Bob Gillespie, Robert Gillespie Associates, WA
Ron Gillespie, Central Kitsap School District, WA
Scott Howard, Perry Public Schools, OH
Alan McAdams, Cornell University, NY
Garry McDaniels, Skills Bank Corporation, MD
Lee McKnight, Massachusetts Institute of Technology
Mike Radlick, New York Department of Education
John Richards, Bolt, Beranek & Newman, Inc., MA
Richard Varn, University of Northern Iowa
Rick Weingarten, Computing Research Association, DC
Al Zeisler, AT&T, NJ

Workshop on Technology-Supported Student Learning: Outcomes, Effectiveness ,and Cost

Steve Carr, Blackstock Jr. High School, CA
Fred Carrigg, Union City School District, NJ
David Dwyer, Apple Computer, Inc., CA
Bob Fazio, Christopher Columbus Middle School, NJ

Dexter Fletcher, Institute for Defense Analyses, VA
Larry Frase, Educational Testing Service, NJ
John Gibson, East Bakersfield High, CA
Bill Hadley, Langley High School, PA
Margaret Honey, Center for Children and Technology, NY
Martin Huntley, Bolt, Beraneck, & Newman, Inc., MA
James Kulik, University of Michigan
Barbara Means, SRI International, CA
Luis Osin, University of Pittsburgh, PA
Beth Stroh, Taylorsville Elementary School, IN
Susan Wolf, Northbrook Middle School, TX

Far West Regional Forum - San Francisco, California

Reesa Abrahams, California Space Grant College
Angela Anastasion, Mt. Diablo Unified School District, CA
Joseph Adwere-Boamal, Oakland Unified School District, CA
Mary Emily Anderson, Bonita Vista High School, CA
Jim Avallone, Robert Frost Middle School, CA
Roger Barnes, Santa Clara Unified School District, CA
Mike Berry, Dixon High School, CA
Kathi Bosworth, San Benito High School District, CA
Eric Boutwell, San Francisco Unified School District, CA
Bruce Bullock, ISX Corporation, CA
Terry Cannings, Pepperdine University, CA
Robert Carlitz, Project Common Knowledge, CA
Mark Chow, Math/Science Nucleus, CA
Kim Clawnan, Waialua, HI
P. Gregory Conlon, California Public Utilities Commission
Norah Corbett, Lodi Unified School District, CA
John Cradler, Far West Laboratory, CA
Bruce Daley, Clark County School District, NV
Sam Dederian, San Francisco Unified School District, CA
Ed Eusebio, Dixon Unified School District, CA
Richard Fabian, San Diego Unified School District, CA
Michael Frisbie, Computer Curriculum Corporation, CA
June Fujitani, Waialua Elementary, HI
Jill Fulton, Pomona Unified School District, GA
Lucia Galindo, Southern California Edison
Nancy Gilbertson, Educational Services Division
Susan Goldsmith, Scottsdale School District, AZ
Mary Lu Graham, California Department of Education
Fay Haisley, University of the Pacific, CA
Bev Hamilton, California Software Clearinghouse
Patricia Hanlon, California Federation of Teachers
Mildred Higashi, Hawaii Department of Education
Richard Hill, Monrovia Unified School District, CA
Ginny House, Tenth Planet, CA
Geri Ichimura, Dole Intermediate School, HI
Jean Jacobson, Mt. Diablo Unified School District, CA
Eric Kanemoto, Highlands Intermediate Middle School, HI
M.G. Kelly, California State University - San Marcos
Don Lake, TEAMS, CA
Carla Lane, Far West Laboratory, CA

Howard Lappin, Foshay Learning Center, CA
Arlene Lee, Hawaii State Teachers Association
Mark Leon, NASA - Ames Research Center
Gregory Little, Computer Curriculum Corporation, CA
Laurie Mack, Parent
Michael Malachowski, City College of San Francisco, CA
Erika Jane Maria, Resource Teacher
Kam Matray, Monterey Peninsula Unified School District, CA
Dave Meaney, Sacramento County
David Medfis, High School Teacher, SF
Mary Jane Mikuriya, San Francisco Unified School District, CA
Joyce Miller, Pomona Unified School District, CA
Wanda Moore, MRC - Pacific Region, HI
Alta Nagel, Computer Curriculum Corporation, CA
Peggy Newgarden-Seals, Berkeley PTA Council, CA
Joseph Oakey, Autodesk Foundation, CA
Sharon Oldham, Alameda County Office of Education, CA
Irene Oliva, Southern California Edison
Mary Pearson, El Centre School District, CA
Leticia Perez, ARC Associates, CA
Judy Phillips, Home Savings of America, CA
Diane Pico, Berkeley Unified School District, CA
Marcus Pottenger, Dole Intermediate School, HI
Michael Powell, Pacific Bell, CA
Bonnie Price, Whittier City School District, CA
Fred Rasbin, National Center for Manufacturing Sciences
Jim Ratcliff, Glen County Office of Education, CA
Fran Rebello, Chico Unified School District, CA
Saul Rockman, Rockman, et al., CA
David Savaglio, Pomona Unified School District, CA
Karen Schroeder, San Benito High School District, CA
Lyn Scott, Berkeley Unified School District, CA
Jackie Siminitus, San Mateo, CA
Leslie Sol, Smart Valley, Inc., CA
Ruth Solomon, Arizona State Senate
Linda Spatz, Berkeley Unified School District, CA
David Stronck, California State University, Hayward
Connie Struve, Pomona Unified School District, CA
Carole Teach, California Department of Education
Tesh Tesfaye, GateCom, CA
Art Tibbetts, Bakersfield City School District, CA
Susie Turner, San Francisco Unified School District, CA
Brenda Walker, Amador County, CA
June Webb-Vignery, Metropolitan Education Commission, AZ
Daniel Weiler, RPP International, Inc., CA
Beverly White, S.H. Cowell Foundation, CA
Duke Williams, Laguna Salada Union School District, CA
Leona Williams, ECT Technolink Foundation, CA
Garth Winckler, United Way of Southern Nevada
Sr. M. Joanne Wittenbery, Archdiocese of Los Angeles, CA
Dale Wright, Consortium on School Networking
Coleman Young, Lawrence Livermore National Laboratory, CA
Anne Zawodniak, Pinal County School Office, AZ

Southeast Regional Forum - San Antonio, Texas

Velinda Acosta, Northside Independent School District, TX
Walter Ague, Uniforce/ASTWP, TX
Jacquelyn Alexander, Our Lady of the Lake University, TX
Robert Alfaro, Premont Independent School District, TX
Alex Alonso, Career and Technical Academy
Joseph Andreis, Sandia National Laboratories, NM
Carlos Atencio, Northern New Mexico Network
Stacy Avery, Northside Independent School District, TX
John Beck, Southwest Texas State University
Mark Blount, Communities In Schools-San Antonio, TX
Maria Burrows, Killeen Independent School District, TX
Willie Calderon, Bernalillo Public Schools, NM
Alex Castillo, South San Antonio Independent School District, TX
Mary Rose de Baca, Bernalillo Public Schools, NM
Carlos Cisneros, New Mexico Legislature
Martha Cole, Las Cruces Public School, NM
Brenda Collins, Sun City Elementary, LA
Mary Conrad, Devine Independent School District, TX
Isa Covio, Texas Commission for the Blind
Thomas Crespin, Bernalillo Public Schools, NM
John Curran, Oklahoma State Department of Education
Kerry Davidson, Louisiana Board of Regents
MaryAnn DeArmond, San Antonio College, TX
Margaret Dike, New Mexico Parent Teacher Association
Margaret Erling, Tulsa Public Schools, OK
Barbara Erwin, University of Houston, TX
Barbara Ferguson, St. John Public Schools, LA
Anna Catherine Ferguson, Ascension Parrish School Board, LA
J.B. Flatt, Oklahoma Association of Secondary School Principals
Sheryl Flowers, Bridge Creek Schools, OK
Barbara Forsberg, University of Texas at Arlington
David Foster, Southwest Educational Development Laboratory, TX
Martha Francis, Southern Methodist University, TX
Mel Fratzke, University of Arkansas
Mary Fuller, East Texas State University
J. Placido Garcia, Jr., Legislative Education Study Committee, NM
Pascual Gonzalez, Northside Independent School District, TX
Roger Guevara, Edgewood Independent School District, TX
Leroy Gunnle, Bernalillo Public Schools, NM
John Hanley, Louisiana Department of Education
Trent Hill, Steven F. Austin State University, TX
Kathy Hogan, Humble Independent School District, TX
Nancy Hollis, Education Service Center, Region VI, TX
Peter Horoschak, Albuquerque Public Schools, NM
Christine Jones, Louisiana Department of Education
Guy Jones, TX
John Juaz, New Mexico Highlands University
Susan Kato, Sandia National Labs, NM
W.N. Kirby, TX
Tony Kneupper, Devine Independent School District, TX
Don Knezek, Education Service Center, Region 20, TX
Judith Kovacs-Long, San Antonio College, TX

Linda Kratz, United Cerebral Palsy, TX
Sharon Krueger, Plano Independent School District, TX
Beverly Lathem, Southwestern Bell Telephone Co., TX
RoseMary Lawson, City of San Antonio, TX
R.M. Lockerd, Texas Instruments
Stephen Maas, New Mexico Department of Labor
Elaine Martinez, Texas Education Agency
Ward McCain, Bryan Independent School District, TX
Samuel McCarter, Dallas County Community College, TX
Jo McCollum, Harlandale Independent School District, TX
Billie Meador, Texas Instruments
Hobart Means, Rose State College, OK
Bill Miller, Louisiana Department of Education
Bill Miller, San Antonio Caller, TX
Nancy Miller, Woodsboro Independent School District, TX
Anne Mitchell, Texas Education Agency
John Mitchell, Texas Education Agency
Andy Montez, Hounston Community College, TX
Gloria Moore, SELCO Special Education Co-op, TX
Arthur Morales, Sandia National Laboratories, NM
Sheila Nicholls, Education Service Center, Region 20, TX
Joe Owens, Arkansas Family Network
Allan Parker, Texas Justice Foundation
Jim Parrish, Crowleys Ridge Education Cooperative, AR
Gene Pekah, ITAC Five, OK
Michaelene Perry, St. Elizabeth Hospital, CA
J. Gilberto Quezada, South San Antonio
Independent School District, TX
David Rainey, Arkansas School for Mathematics and Sciences
Eubenia Rangel, Huantes Learning Center, TX
Beverly Reed, Arkansas Leadership Academy
Katie Reed, Northside Independent School District, TX
Janinne Riggs, Governor's Office, Arkansas
Nancy Robbins, Education Service Center-Region 20, TX
Emmalou Rodriguez, Board of Education, NM
Doug Rogers, Baylor University, TX
Rena Salazar, New Mexico State Department of Education
Lucinda Sanchez, Monte Vista Elementary, NM
Charles Schmitz, Baylor University, TX
Liz Schmitz, Center for Occupational Research and
Development, TX
Herb Schulze, Lockhart Independent School District, TX
Debbie Seibel, New Mexico Congress of Teachers
Mary Louise Sena, Bernalillo Public Schools, NM
Patricia Sermas, Pasadena Independent School District, TX
Neil Sharp, SBC Communications
Sarah Sloan, DuPont, TX
Catherine Smith, New Mexico State Board of Education
Charles Smith, Louisiana Department of Education
Kurt Steinhaus, New Mexico Department of Education
Lu Stephens, Ft. Stockton Independent School District, TX
Monique Timberlake, U.S. Department of Labor/ETA,
Region VI, TX
Thomas Tocco, Ft. Worth Independent School District, TX

Lorraine Trawick, John Marshall High School, TX
Betty Turner, Association of Gifted and Talented Students, LA
Mark Vantilby, Louisiana Systemic Inititiatives Program
Charles Watson, Arkansas Department of Education
Barbara Wave, Consultant, OK
Jan West, Houston Area Urban League, TX
John Whitley, Sandia National Laboratories, NM
Sheryl Williams, New Mexico House of Representatives
Tara Williams, Ft. Stockton Independent School District, TX
Maria Wolfe, Office of U.S. Senator Jeff Bingaman, NM
Betsy Yost, New Mexico Highlands University
Rita Zerr, Tulane University, LA

Midwest Regional Forum - Kansas City, Missouri

Libby Adams, Troost Academy, MO
Raymond Armstrong, Des Moines Public Schools, IA
Max Atwell, School District 232, KS
Sara Aufdernberge, Topeka, KS
Everett Bake, Pan Education Institute, MO
Tammy Barry, Nebraska Legislature
Keith Bartels, University of Nebraska
Georganna Beachboard, Missouri Department of Education
Ralph Beachman, MCC, MO
Bob Beeder, Nebraska Department of Education
Barbara Bichelmeyer, Kansas University
Philip Brody, St. Louis Public Schools, MO
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Steve Coffman, Department of Elementary and Secondary Education, MO
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Appendix D
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