A Retrospective on Twenty Years of Education Technology Policy

By

Katie McMillan Culp, Margaret Honey, & Ellen Mandinach
Education Development Center
Center for Children and Technology

U.S. Department of Education, Office of Educational Technology
John Bailey, Director

October 2003

This paper was commissioned to support the development of the National Education Technology Plan (see http://www.NationalEdTechPlan.org) by the American Institutes for Research (Douglas Levin, Project Director) under contract to the U.S. Department of Education (Contract no. ED-01-CO-0026/0017). The content does not necessarily reflect the views of the Department or any other agency of the U.S. Government.

No Child LEFT BEHIND

ABSTRACT

Twenty years ago, *A Nation at Risk* (1983) recommended "computer science" as one of the five "new basics" to be included in high school graduation requirements. Since then, American schools have made dramatic improvements in their technological capacity, driven largely by public and private investments over the past ten years of more than $40 billion dollars in infrastructure, professional development and technical support (Dickard, 2003). K-12 educators have also made great strides in their readiness and ability to use technology to redefine the boundaries of the school building and the school day, to improve the quality and accessibility of the administrative data that informs their work, and most importantly, to foster the learning of core content and the development of students' skills as communicators, researchers, and critical consumers of an ever-expanding world of information. However, policymakers, practitioners and the public all recognize that much remains to be done in each of these areas.

This paper provides an overview and analysis of twenty years of key policy reports addressing the challenges and opportunities involved in integrating technology into K-12 education in the United States. The report summarizes recommendations made in these reports, and comments on the shifting rationales for and expectations of educational technology investments that have shaped those recommendations over time. In undertaking this analysis, we have been guided by three key questions:

1. Why have we chosen to invest in educational technologies? What rationales have motivated and shaped these investments over time?

2. What have been identified as the requisite steps to take in order to ensure that technologies are effectively implemented? What specific recommendations have been given priority over time?

3. What assumptions underlie our vision for how technologies can impact teaching and learning, and how have these changed over time?

This report is intended to contribute to the planning and development of the new National Education Technology Plan (see http://www.NationalEdTechPlan.org). This plan, mandated by the No Child Left Behind legislation (ESEA, 2001), will inform and guide policymakers in their efforts to ensure that schools will be able to use technology effectively to support high-quality teaching and learning for all students.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

INTRODUCTION

In 1983, the federal report *A Nation at Risk* included a recommendation that high school graduation requirements include coverage of the "Five New Basics"—English, mathematics, science, social studies, and computer science. Regarding computer science, the Commission on Educational Excellence, which authored the report, specified that all high school graduates should "understand the computer as an information, computation and communication device; [be able to] use the computer in the study of the other Basics and for personal and work-related purposes; and understand the world of computers, electronics, and related technologies" (National Commission on Excellence in Education, 1983).

Nearly twenty years later, the No Child Left Behind Act of 2001 (NCLB) includes a recommendation that by the eighth grade all students should be technologically literate and repeatedly references technology as an important source of support for teaching and learning across the curriculum. The level of emphasis placed on educational technology in the legislation reflects a growing consensus among educators and the public at large about the importance of technological literacy: the ability to use computers—and a range of technologies not yet anticipated in 1983—to communicate, to locate and manage information, and, perhaps most importantly, to use these tools effectively to support learning the content of "the other basics."

American schools have made great progress since *A Nation at Risk*, improving both their technological capacity and their readiness and ability to use technology to foster the learning of core content and the development of students' skills as communicators, researchers, and critical consumers of an ever-expanding world of information. But, as a recently released report by the Partnership for 21st Century Skills advocates, "To cope with the demands of the 21st century, people need to know more than core subjects. They need to know how to use their knowledge and skills—by thinking critically, applying knowledge to new situations, analyzing information, comprehending new ideas, communicating, collaborating, solving problems, making decisions" (2003, p. 9). By requiring technological literacy in the eighth grade, NCLB takes a significant step toward ensuring that all students will become technologically literate.

Determining how best to support and advance high-quality use of educational technology in K-12 settings has continued to be a prominent concern for both practitioners and policymakers. In order to inform continued efforts in this domain, we have reviewed the policy recommendations made in major educational technology reports issued by federal agencies, blue ribbon panels, and private-sector consortia since the publication of *A Nation at Risk*. This report presents a summary of and reflections on those recommendations, as well as commentary on the shifting rationales for and expectations of educational technology investments that have shaped those recommendations over time.

This report is intended to contribute to the planning and development of the new National Education Technology Plan. This plan, mandated by the NCLB legislation, will inform and guide policymakers in their efforts to ensure that schools will be able to use technology effectively to support high-quality teaching and learning for all students.

In order to create a plan that both learns from the lessons of past policy initiatives and that takes an aggressive approach to setting goals for the use of education technology in the 21st Century, it is important to review and reflect upon past recommendations made by experts to policymakers over the past twenty years on how best to invest in technology for education. In undertaking this analysis we have been guided by three key questions:

1. Why have we chosen to invest in educational technologies? What rationales have motivated and shaped these investments over time?

2. What have been identified as the requisite steps to take in order to ensure that technologies are effectively implemented? What specific recommendations have been given priority over time?

3. What assumptions underlie our vision for how technologies can impact teaching and learning, and how have these changed over time?

How These Reports Were Selected

This paper examines key policy documents produced over the last 20 years (1983-2003). These reports were selected through a two-stage process. First, we sought nominations from leaders in the educational technology field, asking them to list what they considered to be the "ten most important policy reports regarding educational technology of the last twenty years." Responses to this request produced a core group of reports mentioned by all or nearly all the nominators, as well as a longer list of reports mentioned less frequently. We then reviewed all the nominated reports with reference to the following criteria:

- Reports must have been intended to reach and be relevant to a wide audience;

- Reports must focus specifically on the topic of educational technology (with the exception of *A Nation at Risk*);

- Reports must focus primarily (but not necessarily exclusively) on formal K-12 education;

- Reports must offer a distinct perspective on the current and future roles technology can or should play in K-12 education;

- Reports must provide either concrete recommendations for policymakers for achieving those ends or relate a body of research to a specific set of goals regarding the integration of technology into K-12 education; and

- While reports may review research literature, provide overviews of current data on technology use or penetration, and/or make recommendations for action by other audiences, these elements must be secondary to a primary goal of advancing a particular vision for improving the role of educational technology in K-12 schools.

Using these criteria, we generated a list of 28 reports, which were all included in the analysis presented in this paper. This group of reports includes two prior national technology plans; summary

reports from congressional and presidential commissions; and reports from professional and governmental organizations such as the National Research Council, the Education Commission of the States, and the National Association of State Boards of Education. It also includes two important series of documents produced during the 1980's and 1990's: reports from the Office of Technology Assessment of the U.S. Congress, and the CEO Forum's reports on educational technology. See Table 1 for a complete listing of the titles and authors of these reports. Complete references for these reports, as well as for other research and policy documents cited in the course of our discussion, are included in the bibliography of this paper.

TABLE 1

Educational Technology Policy Documents Included in this Report, by Date Of Publication

Educational Technology Policy Documents Included in This Report	
1983	A Nation at Risk National Commission on Excellence in Education
1988	Power On! New Tools for Teaching and Learning U.S. Congress, Office of Technology Assessment
1989	Linking for Learning: A New Course for Education U.S. Congress, Office of Technology Assessment
1992	Testing in American Schools: Asking the Right Questions U.S. Congress, Office of Technology Assessment
1993	Adult Literacy and New Technologies: Tools for a Lifetime U.S. Congress, Office of Technology Assessment
1995	Connecting K-12 Schools to the Information Superhighway McKinsey & Co.
	Education and Technology: Future Visions U.S. Congress, Office of Technology Assessment
	Teachers and Technology: Making the Connection U.S. Congress, Office of Technology Assessment
1996	The Learning Connection: Schools in the Information Age The Benton Foundation
	Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge. A Report to the Nation on Technology and Education U.S. Department of Education
	Kickstart Initiative: Connecting America's Communities to the Information Superhighway National Information Infrastructure Advisory Council (NIIAC)

TABLE 1 (Continued)

Educational Technology Policy Documents Included in this Report, by Date Of Publication

Educational Technology Policy Documents Included in This Report (continued)	
1997	Computers and Classrooms: The Status of Technology in U.S. Schools Educational Testing Service
	Overview of Technology and Education Reform U.S. Department of Education
	Report to the President on the Use of Technology to Strengthen K-12 Education in the United States President's Committee of Advisors on Science and Technology
	School Technology and Readiness Report: From Pillars to Progress The CEO Forum on Education and Technology
1999	School Technology and Readiness Report. Professional Development: A Link to Better Learning The CEO Forum on Education and Technology
2000	The National Technology Education Plan, e-Learning: Putting a World-Class Education at the Fingertips of All Children U.S. Department of Education
	The Power of the Internet for Learning Web-based Education Commission
	The Secretary's Conference on Educational Technology, Measuring Impacts and Shaping the Future U.S. Department of Education
	School and Technology Readiness Report. The Power of Digital Learning: Integrating Digital Content The CEO Forum on Education and Technology
2001	Any Time, Any Place, Any Path, Any Pace: Taking the Lead on e-Learning Policy National Association of State Boards of Education
	Education Technology Must Be Included in Comprehensive Legislation CEO Forum on Education and Technology
	Investing in K-12 Technology Equipment: Strategies for State Policymakers Education Commission of the States
	Student Achievement in the 21st Century: Assessment, Alignment, Accountability, Access, Analysis CEO Forum on Education and Technology
2002	Technically Speaking: Why All Americans Need to Know More About Technology National Academy of Engineering, National Research Council
	Visions 2020: Transforming Education and Training Through Advanced Technologies U.S. Department of Commerce, Technology Administration
2003	Learning for the 21st Century Partnership for 21st Century Skills
	The Sustainability Challenge: Taking Ed-Tech to the Next Level Benton Foundation, EDC/Center for Children & Technology

WHY INVEST?

Policymakers are faced with a seemingly infinite range of possible interventions to support in their efforts to enhance and improve American K-12 schools. Over the last twenty years, how have we chosen to justify investing in educational technologies? To what extent has technology been seen as an essential component of teaching, learning, and the overall functioning of schools and school systems, and how do these reports seek to enlist the support of policy audiences? We found that rationales for investment in educational technology draw on three key themes that are repeatedly touched upon as authors seek to communicate the immediacy and urgency of their cause.

Technology as a Tool for Addressing Challenges In Teaching and Learning

Policy documents repeatedly describe matches between specific capabilities of various technologies and persistent challenges to the delivery, management, and support of effective teaching and learning experiences. Key opportunities frequently cited in these reports include delivering instruction to geographically dispersed audiences; helping students collect and make sense of complex data; supporting more diverse and process-oriented forms of writing and communication; and dramatically broadening the scope and timeliness of information resources available in the classroom. For example, one report explains that specific technologies can "extend teaching and learning processes," in specific domains (OTA, 1988), such as using electronic probes to expand data collection and analysis in science classes, and using distance learning systems to expand the reach of teachers in specialized subject areas to broader populations of students. A 1992 report from OTA raises another important issue by describing how computer-based testing could support more efficient and instructionally useful administration of achievement tests, while illustrating how multimedia resources could also support the creation, archiving and analysis of records of student work that make possible the assessment of more complex dimensions of learning and cognition through performance and portfolio assessments.

Technology as a Change Agent

Many reports present strong assertions that technology can catalyze various other changes in the content, methods, and overall quality of the teaching and learning process, most frequently, triggering changes away from lecture-driven instruction and toward constructivist, inquiry-oriented classrooms. The degree of emphasis placed on these expectations varies considerably across these reports, but this image of technology as a catalyst for change is almost universally shared. For example, several of the reports that focus on teachers and their needs and interests (CEO Forum, 1997, 1999; NASBE, 2001; OTA, 1989, 1995b) emphasize the importance of viewing technology as a class of tools that must be well-matched to specific content areas and learning goals, and make clear the material and professional conditions that must be in place before teachers can begin the process of assimilating technology into their day-to-day instruction. Other reports, focused on the need for further development of educationally-relevant digital content and new technological tools for learning (CEO Forum, 2000; U.S. Department of Commerce, 2002), place a greater emphasis on the transformative potential of the tools themselves. Although these reports also reference the importance of adequately trained and motivated teachers, they foreground the potential of the digital

tools themselves to change the learning environment and the teaching process, making it more flexible, more engaging, and more challenging for students.

Technology as a Central Force in Economic Competitiveness

References are also frequently made to economic and social shifts that have made technology skills critical to the future employment of today's students, and more broadly, to the importance of technology innovation to maintaining the economic and political dominance of the United States globally. The recently released report on *Learning for the 21st Century*, from the Partnership for 21st Century Skills (2003), makes this case strongly, reviewing the impact of technology on the job market, the flow of information and resources in a global marketplace, and the impact of digital technologies on daily life. Perhaps most importantly, both this report and others that have emphasized the global context of the call for all forms of educational improvement (PCAST Panel on Educational Technology, 1997; U.S. Department of Education, 2000c) explain that the ability to expect and adapt to change is fundamental to success in the job market and to active citizenship. The report *Technically Speaking: Why All Americans Need to Know More About Technology* provides a compelling argument for the urgency of investing in technological literacy, broadly defined, stating that increasing the technological literacy of the public would improve decision making, increase citizen participation, support a modern workforce, enhance social well-being, and narrow the digital divide (National Academy of Engineering, 2002, Chapter 2).

These three rationales for investing in educational technology surface again and again throughout the last twenty-years. They are also highly interconnected. At their core, each of these rationales is based on recognition that technology is the embodiment and the means of much of the social and economic change of the past century. There is also an acknowledgement that integrating technologies into the instructional fabric of teaching and learning in our society requires commitment, focus, and resources from multiple stakeholders. Policy documents have been used consistently to garner support and sustain momentum over time.

WHAT RECOMMENDATIONS HAVE BEEN MADE TO SUPPORT AND SUSTAIN INVESTMENTS?

The large majority of the reports reviewed in this analysis provide recommendations to policymakers and other stakeholders of actions to be taken in order to provide the political support, material conditions, and research-based knowledge necessary to establish high quality, technology-rich learning environments in American schools. A core task of this review was to examine the specific recommendations that were made and to determine whether and how these recommendations have changed over time. Our review suggests that there are six recommendations that have remained highly consistent over time, and a seventh that has emerged as a result of the growth of telecommunications technologies. Many of these recommendations overlap and interconnect, reflecting the particular importance of using multiple avenues simultaneously to support effective and sustained integration of technology into schools. Additionally, while the substance of these recommendations has remained largely intact over time, the particulars of each issue have shifted in response to the significant progress made in a number of relevant areas, most prominently in infrastructure investment and content development.

The seven key recommendations are:

1. Improve access, connectivity, and requisite infrastructure;

2. Create more, high-quality content and software;

3. Provide more, sustained, high-quality professional development and overall support for teachers seeking to innovate and grow in this domain;

4. Increase funding from multiple sources for a range of relevant activities;

5. Define and promote the roles of multiple stakeholders, including the public and private sectors;

6. Increase and diversify research, evaluation, and assessment; and

7. Review, revise and update regulations and policy that affect in-school use of technology, particularly regarding privacy, and security.

See Table 2 for a summary of those recommendations specifically discussed in each of the reports under consideration. This table includes the 24 (out of 28) reports that provide explicit recommendations. Four of the reports (*A Nation at Risk; Computers and Classrooms: The Status of Technology in U.S. Schools; An Overview of Technology and Education Reform;* and *Visions 2020*) do not provide explicit recommendations for policymakers, but do provide important overviews of dominant perspectives on education and technology at particular moments over the past twenty years, and so were included in our broader discussion.

TABLE 2

Which Reports Include Which Recommendations?

Date	Title	Access	Content	P.D.	Funding	Stakeholders	Research	Regulations
1988	Power On! New Tools for Teaching and Learning U.S. Congress, Office of Technology Assessment	X	X	X			X	
1989	Linking for Learning: A New Course for Education U.S. Congress, Office of Technology Assessment	X		X			X	X
1992	Testing in American Schools: Asking the Right Questions U.S. Congress, Office of Technology Assessment						X	X
1993	Adult Literacy and New Technologies: Tools for a Lifetime U.S. Congress, Office of Technology Assessment	X	X	X	X		X	X
1995	Connecting K-12 Schools to the Information Superhighway McKinsey & Co.	X	X	X	X	X		
	Education and Technology: Future Visions U.S. Congress, Office of Technology Assessment	X			X		X	
	Teachers and Technology: Making the Connection U.S. Congress, Office of Technology Assessment	X	X	X	X	X	X	X
1996	The Learning Connection: Schools in the Information Age The Benton Foundation	X	X	X		X		
	Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge. A Report to the Nation on Technology and Education U.S. Department of Education	X	X	X	X	X	X	X
	Kickstart Initiative: Connecting America's Communities to the Information Superhighway National Information Infrastructure Advisory Council (NIIAC)	X	X	X	X	X		X

TABLE 2 (Continued)

Which Reports Include Which Recommendations?

Date	Title	Access	Content	P.D.	Funding	Stakeholders	Research	Regulations
1997	Report to the President on the Use of Technology to Strengthen K-12 Education in the United States President's Committee of Advisors on Science and Technology, Panel on Educational Technology	X		X	X		X	
	School Technology and Readiness Report: From Pillars to Progress The CEO Forum on Education and Technology	X	X	X	X	X	X	
1999	School Technology and Readiness Report. Professional Development: A Link to Better Learning The CEO Forum on Education and Technology	X	X	X		X		X
2000	The National Technology Education Plan, e-Learning: Putting a World-Class Education at the Fingertips of All Children U.S. Department of Education	X	X	X	X	X	X	X
	The Power of the Internet for Learning Web-based Education Commission	X	X	X	X	X	X	X
	The Secretary's Conference on Educational Technology, Measuring Impacts and Shaping the Future U.S. Department of Education		X			X	X	
	School and Technology Readiness Report. The Power of Digital Learning: Integrating Digital Content The CEO Forum on Education and Technology		X	X	X	X	X	

TABLE 2 (Continued)

Which Reports Include Which Recommendations?

Date	Title	Access	Content	P.D.	Funding	Stakeholders	Research	Regulations
2001	Any Time, Any Place, Any Path, Any Pace: Taking the Lead on e-Learning Policy National Association of State Boards of Education	X		X		X		X
	Education Technology Must Be Included in Comprehensive Legislation CEO Forum on Education and Technology	X	X	X	X		X	
	Investing in K-12 Technology Equipment: Strategies for State Policymakers Education Commission of the States	X		X	X	X		X
	Student Achievement in the 21st Century: Assessment, Alignment, Accountability, Access, Analysis CEO Forum on Education and Technology	X	X	X	X		X	
2002	Technically Speaking: Why All Americans Need to Know More About Technology National Academy of Engineering, National Research Council		X	X	X	X	X	X
2003	Learning for the 21st Century Partnership for 21st Century Skills		X	X		X		
	The Sustainability Challenge: Taking Ed-Tech to the Next Level Benton Foundation, EDC/Center for Children & Technology	X	X	X	X		X	

It is important to note that this analysis is not intended to fully capture the specificity and range of all of the recommendations made in each of the reports discussed here. In many cases, these reports tailor their recommendations to respond to a particular issue within the field of education technology, as, for instance, in *Linking for Learning* (OTA, 1989), which urges an expansion of professional development opportunities for teachers specifically related to distance learning technologies. However, this recommendation for further technology-related professional development is repeated, in general, over and over again across many of these reports. The same is true for each of these seven themes. Therefore, in recognition of the remarkable strength of the consensus across these many authors and twenty years of work, we have chosen to highlight the broad commonalities across these reports and the recommendations they make for future action by policymakers.

Improving Access, Connectivity, and Infrastructure

All of the reports we reviewed consistently recognize the need to install sufficient hardware in all schools. A number of reports use summary data from the National Center for Education Statistics (NCES) and other sources to document the dramatic improvement over the past twenty years in the installed hardware base in schools, and in Internet access in classrooms (see especially the CEO Forum reports, as well as U.S. Department of Education, 2000c). The belief reflected in earlier reports was that having enough technology infused in schools would be the first step toward the widespread and effective use of educational technology (OTA, 1988). However, in more recent reports, particularly since 1997, researchers and policymakers have begun to recognize that physical access to hardware and Internet connectivity is only one dimension of true technology accessibility (Coley, Cradler, & Engel, 1997; PCAST Panel on Educational Technology, 1997; U.S. Department of Education, 2000a, 2000b). Key to this shift was the "call to action" of the NIIAC's Kickstart Initiative (NIIAC, 1996), which grounded its enthusiasm over the potential of the Internet in a vision of community-oriented, grassroots engagement with the Internet as a site for education and the exchange of ideas. In these late-90s reports, "accessibility" refers not only to physical access, but also to access to relevant and appropriate content, to adequate support and training, and the ability to make use of technology to both create and consume information and ideas. While recommendations made in these reports stress significant gains made in this area, they also underscore that both access and accessibility continue to be an issue. Maintaining high-quality and equitable access to technology over the long term is a central focus in all the documents, with some, specifically, discussing the importance of developing sustainability plans for technology funding (McKinsey & Company, 1995; PCAST Panel on Educational Technology, 1997).

By the mid 1990's, several reports provide detailed recommendations regarding technology access and associated costs. Most prominent among these is the McKinsey & Company report, *Connecting K-12 Schools to the Information Superhighway*, which outlined several proposed templates for types of technical infrastructures that federal and local agencies could consider committing to on a large scale, and outlined anticipated costs associated with these plans. The PCAST Panel on Educational Technology report (1997) urged a continued level of support for technology through Title I to ensure equitable and universal access. As the Internet began to emerge, recommendations regarding access addressed the need for Internet connections in addition to hardware and software.

By the beginning of the new millennium, despite the consistent emphasis placed on ensuring adequate access to technology for teachers and students, it was clear that establishing reliable universal access still was an issue (see the NCES annual reports on Internet access in schools for details, summarized in NCES, 2002). This reflected the scope of the need for basic infrastructure investments in schools, a concept the E-Rate made clear: schools faced many ancillary expenses associated with establishing functioning intra- and extranets, such as major electrical upgrades and asbestos removal (for a summary of the E-Rate program, which provides discounts on telecommunications equipment and Internet access to schools and libraries, see http://www.sl.universalservice.org/). But the persistence of "access" as a prominent issue also reflected the increasingly broad awareness of the scope of the problem being addressed, as was reflected by the shift toward "accessibility" as the core goal, as discussed above. Working toward more affordable, convenient, reliable, sustainable and easy to use technology as well as adequate and relevant content resources and training continue to be only partially-achieved steps toward a goal of creating technology-rich teaching and learning environments.

Creating More High-Quality Content and Software

A discernable trend can be traced from the earliest to the most recent reports: the shift in educational software demand toward content quality, curriculum integration and ease of access. The earliest discussions of content emphasized the need for large-scale integrated learning systems, as well as stand-alone software (OTA, 1988). By the mid 1990's, recommendations more frequently described the need to develop quality software packages that were age appropriate, engaging, relevant to the content areas, pedagogically sound, and readily implementable and integratable into existing curricula (see CEO Forum 1997, 2000; Conte, 1996; OTA, 1995a; PCAST Panel on Educational Technology, 1997; U.S. Department of Education, 1996, 1997). These reports stressed the need to emphasize content and pedagogy, not just the hardware requirements. This shift reflects a growing recognition among both commercial and academic content developers that effective software and online learning resources must be an integral part of the curriculum. Despite the rapid expansion and diversification of the educational software market and the proliferation of educational software, many reports stressed the need for continued innovation and improvement in the quality of software and web-based resources (see PCAST Panel on Educational Technology, 1997, for a summary of the educational software market during that period). Most recently, as virtual learning environments have begun to emerge, there has been a corresponding recognition for the need to integrate digitized content and network applications into federal, state, and local standards and frameworks to enable developers to better produce appropriate materials (see CEO Forum, 2000, 2001b). There is a further recognition that both the public and private sectors must collaborate to produce such quality online and digitized content, a point strongly emphasized in the Web-based Education Commission's report (Web-based Education Commission, 2000).

Providing High Sustained, Quality Professional Development

Teacher professional development has been one of the enduring themes across the past twenty years and is often highlighted in these reports as the single most important step toward the infusion of technology into education. *A Nation at Risk* (National Commission on Excellence in Education, 1983) recognized the overall need for new teacher training methods to be developed and the need to attract more able candidates to the teaching profession. This need is addressed consistently in the reports we reviewed, including both in-service and pre-service teacher education.

However, in-service professional development is consistently addressed in more depth and detail in these reports than preservice teacher education.

Throughout the late 80's and early 90's, the OTA report series stresses the importance of expanding and improving professional development opportunities for teachers seeking to improve their use of technology in the classroom (see OTA, 1988, 1989, 1992, and particularly 1995b). By the mid- to late 1990's, the reports increasingly emphasize the need for enhanced professional development opportunities, incentives, state certification requirements, preservice curricula, and inservice programs—the CEO Forum report on professional development (1999) places a particular emphasis on the need to address both preservice and inservice teachers. These recommendations were based in part on NCES survey data that demonstrated that only approximately 20% of teachers felt that they were adequately prepared to use educational technology in their teaching (U.S. Department of Education, 2000c). In addition to the CEO Forum reports, the PCAST Panel on Educational Technology (1997), the 2000 National Technology Plan (the *e-Learning* report, U.S. Department of Education, 2000a) and the report of the Web-based Education Commission (Web-based Education Commission, 2000) all identified professional development as a crucial element in any coordinated approach to improving technology use in schools, and strongly recommended improving and expanding the kinds of training opportunities available to teachers. A report from the National Association of State Boards of Education (2001) also identifies the link between professional development and achieving equity in educational opportunities for K-12 students, arguing that only with adequate professional development will all teachers be able to put technology to use in ways that will truly enhance student learning.

More broadly, all of these reports recognized the need for new and emerging roles for teachers, the involvement of the majority of teachers in local technology initiatives, and the relevance of the more general push for the professionalization of teaching to the effort to create a technology-using teacher workforce. The *e-Learning* report (U.S. Department of Education, 2000a), for example, advanced three recommendations:

- Improve the preparation of new teachers, including their knowledge of how to use technology for effective teaching and learning;
- Increase the quantity, quality, and coherence of technology-focused activities aimed at the professional development of teachers; and
- Improve real-time instructional support available to teachers who use technology.

Increase Funding

Nearly every report we reviewed recognizes the need for additional funding to establish an adequate level of technology and training in schools, but formal budgetary recommendations do not appear until the mid 1990's. The PCAST Panel on Educational Technology report recommended that five percent of all public, pre-college expenditures be devoted to technology (PCAST Panel on Educational Technology, 1997). Such expenditures, the report suggested, should not be in the form of bond issues, but instead be ongoing line items in schools' operating budgets. Correspondingly, the report recommended that cost-effectiveness analyses be undertaken to provide an important perspective on measuring technology's impact on schools. The McKinsey report (McKinsey & Company, 1995), at the same time, recommended that funding needs for educational technology can

be met by "reducing costs, reprogramming existing educational funds, and obtaining funds from new sources," both from the public and private sectors. More recent reports stress the need for sustained funding, also by both traditional and new sources. The report of the Web-based Education Commission (Web-based Education Commission, 2000), in noting that funding is required for more than just wiring schools, recommends: (a) new public/private partnerships; (b) sustained, long-term funding; and (c) tax incentives to encourage investments in infrastructure.

Define and Promote the Roles of Multiple Stakeholders

A variety of stakeholders from the public and private sectors play essential roles in implementing and sustaining the technological infrastructure in education. Since 1988, policy reports have emphasized the importance of governmental support, especially at the Federal level, but also at the state and local levels. The earliest reports recommend a long-term, sustained commitment for the development of the technological infrastructure, requiring major input at the Federal level (OTA, 1988, 1989). Given the nature of education funding, much of the burden for funding would also, inevitably, occur at the state and local level, but these reports clearly recommend that given the overwhelming cost of establishing an adequate technological infrastructure, all levels of government should think creatively about building a long-term and large-scale strategy for meeting schools' infrastructure and technical needs. Many reports also note that this investment would require not only governmental spending but also input, leadership, and financial support from public/private partnerships, local communities, and professional organizations representing both educators and employers (McKinsey & Co. 1995; OTA, 1988; PCAST Panel on Educational Technology, 1997; U.S. Department of Education, 1996; Web-based Education Commission, 2000).

A range of roles are described for the federal government throughout these reports, including: articulating a comprehensive vision for the use of education technology (OTA, 1988); seeding innovation in hardware and software development (U.S. Department of Education, 1996); showcasing promising initiatives and highlighting best practices (Web-based Education Commission, 2000); conducting long-range, strategic planning for education technology and serving as a catalyst for national action (PCAST Panel on Educational Technology, 1997; U.S. Department of Education, 1996, 2000a); providing leadership on the issues of equitable access (U.S. Department of Education, 2000a) and improved professional development (OTA, 1995b); and outlining an agenda for further research and development to understand and demonstrate the potential impact of technology on learning (PCAST Panel on Educational Technology, 1997).

Roles for state and local governments are also discussed consistently and in relation to many of the same issues. These levels of government are exhorted to invest substantially in technology infrastructure (Education Commission of the States, 2001; McKinsey & Company, 1995); provide ongoing support for teachers (CEO Forum, 1999); build community support for technology investment (CEO Forum, 2000); and ensure equitable access for all students (Coley, et al., 1997). States are also particularly relevant in reports that emphasize the importance of aligning technology use with standards, with many reports recommending that states incorporate technology skills into state learning standards and develop assessments that are aligned with those frameworks (see CEO Forum, 2000, 2001a; U.S. Department of Education, 2000c, 2000b). Local governments are encouraged to work with businesses and community leaders to emphasize the skills that will make students productive members of the workforce and community (CEO Forum, 2000; Web-based Education Commission, 2000).

The private sector is also addressed, particularly in the report of the Web-based Education Commission (Web-based Education Commission, 2000) and in the CEO Forum report series (1997, 1999, 2000, 2001a, 2001b). Charges presented to this audience include supporting the development of quality instructional materials, content, and professional development; reinforcing the need for a highly skilled workforce; helping to ensure that all future workers acquire 21st century, life-long learning skills through investment in education, modeling desirable practices in their own workforce development, and leadership at local and national levels. These same reports also place a particular emphasis on parents and families, who are also seen as stakeholders and are encouraged to urge their school systems to integrate technology literacy skills into content areas and to support funding to enable schools to integrate technology into the curricula.

Increase and Diversify Research, Evaluation, and Assessment

The call for research on the impact of educational technology on schools and teaching and learning activities is a final constant theme found over the past twenty years of reports. Every report recommends, at minimum, some sort of research or evaluation of the impact of education technology on students. *Teachers and Technology: Making the Connection*, (OTA, 1995b), for example, points out that funders would be more willing to support technology investment if there were more, and better disseminated, research-based knowledge about the conditions that need to be in place in order for technology to be used effectively. This report goes into some depth in its discussion of the urgency of establishing a program of research that would move away from earlier, comparative research designs focused on the physical activity of interacting with a computer as the primary intervention. Instead, this report advocates a shift in focus toward the systematic examination of new technologies as one among many elements in the educational environment. This would require studying the inter-relationships among new technologies and other factors such as instructional style, content, and social interactions within the classroom. Importantly, this report also notes the need for improved outcome measures that can more appropriately capture the strengths and weaknesses of students' technology-rich work products.

The PCAST Panel on Educational Technology report (1997) also makes a strong case for further support of a coherent but methodologically diversified program of research. This report carefully articulates both the need for clearer evidence regarding the efficacy of a range of specific types of technology use in classrooms and the need to provide both expanded funding and a reasonable timeframe for that research to be produced. This report specifically recommends investment in three areas of research:

1. Basic research in learning-related disciplines and fundamental work on educationally relevant technologies;

2. Early-stage research aimed at developing new forms of educational software, content, and technology-enabled pedagogy;

3. Empirical studies designed to determine which approaches to the use of technology are in fact most effective (PCAST Panel on Educational Technology, 1997).

This report specifically recommends the initiation of "a major program of experimental research" to establish the efficacy and cost-effectiveness of technology use. But the report also explains that:

> *"…The principal goal of such empirical work should not be to answer the question of whether computers can be effectively used within the school. The probability that elementary and secondary education will prove to be the one information-based industry in which computer technology does not have a natural role would at this point appear to be so low as to render unconscionably wasteful any research that might be designed to answer this question alone.*
>
> *Even if it were deemed to be desirable to gather evidence for the overall effectiveness of technology in education, current educational trends would make the interpretation of such research more difficult than was the case in the early days of computer-assisted instruction. Technology has in recent years been increasingly seen not as an isolated addition to the conventional K-12 curriculum, but as one of a number of tools that might be used to support a process of comprehensive curricular (and in some cases, systemic) reform. In such an environment, attempts to isolate the effects of technology as a distinct independent variable may be both difficult and unproductive" (pp. 93-94).*

Finally, this report also recommends that between one and five percent of the all education spending should be devoted to supporting research and development.

While these two reports go into more depth than others regarding recommendation courses and areas of focus for future research agendas, many of the remaining reports provide a very general call for research and development, and for demonstrations and evaluations connecting research to practice. More specific recommendations that at least some component of the research agenda focus on how people learn best with technology, and on the impact of the new technologies on the learning process are frequently made. For example, the National Academy of Engineering's report, *Technically Speaking* (Pearson & Young, 2002), advocates investment in research into "how people learn about technology," as well as the development of assessment tools that would allow longitudinal tracking of the growth of technological literacy among "students and the public" over time.

The fundamental premise of all the recommendations regarding future research is to increase scientific understanding of how technology can improve teaching and learning activities. Several more specific recommendations are made in multiple reports but best summarized and explained in the papers collected in the proceedings of the Secretary's Conference on Understanding the Impact of Technology on Learning (U.S. Department of Education, 2000b). These issues include the need to establish a definition of conditions for effective use; create new measures of progress and indicators of effective use; and design new approaches to assessment and more sensitive evaluation tools. (Other reports that address some or all of these issues include the PCAST Panel on Educational Technology, 1997; and the U.S. Department of Education, 1997, 2000a).

The *e-Learning* report (U.S. Department of Education, 2000a), for example, suggests that research and evaluation will improve the next generation of technology applications for teaching and learning by encouraging state and local evaluations of technology programs and by supporting the dissemination and use of results. There must be a well-defined research agenda, the recommendations explain, that focuses on how people learn through the use of technology. Further, the report asserts in these recommendations that there needs to be a pedagogical base on which to build an understanding of how students learn and how technology-based tools support and assess learning.

Teachers' Tools for the 21st Century (U.S. Department of Education, 2000c) outlines nine policy and research questions that should form the bases for a comprehensive research agenda:

1. How does the use of computers, the Internet and other applications by teachers and students affect student performance, knowledge, and skills?

2. What is the impact of computer and Internet use on the way teachers teach and students learn, and what is the impact more broadly on educational reform?

3. How does the investment in technology compare with other educational innovations, such as smaller classes or individualized instruction, in terms of costs and benefits?

4. What are the types of technologies available in schools (e.g., quality/speed, types of Internet connections, software applications)?

5. What are the organizational changes to schools that will enable the increased use of technology (e.g., administrative efficiency, home-school connections, collegial communication) or the sustainability of technology implementation and use?

6. What are the fiscal expenditures of educational technology at the school, district, state, and national levels?

7. What are the professional development and technical support strategies for enhancing teachers' effective use of technology?

8. What are the duration and types of technology uses for teaching and learning both inside and outside of the school?

9. What are the effects of different types of technology applications on particular types of students (e.g., limited English proficient, special education, gifted and talented)?

Review, Revise, and Update Regulations

Recommendations focusing on the need for new regulations and policies regarding educational technology have emerged relatively recently. In fact, much of the consideration for privacy and security coincided with the Y2K issues at the turn of the new millennium. It was not until 2000 that the policy documents noted the need for new regulations to account for issues that have begun to arise with the proliferation of the Internet and virtual learning environments, with recommendations in this area emerging in reports including the Web-based Education Commission's report (Web-based Education Commission, 2000), the National Association of State Boards of Education's report on e-learning (2001), the CEO Forum report on digital content (2000) and the *Future Visions* report from the U.S Department of Commerce (2002). These reports recognize the need to protect online learners in terms of privacy and security issues. The reports also recognize with the emerging virtual learning environments that there is a need to rethink copyright regulations in terms of dissemination of information on the Internet. One report urged the removal of barriers to purchasing digitized content and networked applications, in an effort to address the pressing need for rich digitized educational materials. Other documents call for reconsidering course requirements for

non-brick and mortar institutions, as well as regulations for accreditation, the provision for credentials, and internal quality review (see the CEO Forum report on professional development, 1999, for discussion of many of these issues).

To What Extent Have These Recommendations Been Acted Upon?

It is interesting to note that although several of these seven recommendations are very clearly and tightly tied to specific goals, most are much less clear about what goals they are intended to help policymakers achieve. Specifically, recommendations concerning funding, development of content and the expansion of professional development can clearly be associated with relatively objective goal states, both related to establishing the *educational environment* in which educational technology might flourish: creating an adequate and accessible technical infrastructure, appropriate content resources, and a prepared, professional teaching force. However, recommendations concerning the mobilization of multiple stakeholders, expansion of the research base, and revision of regulations and policy, while clear in their specifics, do not actually imply any one goal. In fact, these recommendations are made largely in recognition of the challenges involved in establishing high-quality use of technology in K-12 schools and in even defining what constitutes high-quality use.

The PCAST report, as well as the CEO Forum reports, the NASBE report, and others to a lesser extent, recognize this difficulty and preface their recommendations with an acknowledgement of the shifting landscape within which educators are seeking to put technology to use. As these reports recognize, defining one clear, long-term set of goals for the integration of educational technology is difficult because:

- Technologies themselves are multiple, implying different strategies of use and application;
- Technologies themselves are evolving rapidly, often far faster than schools are able to change their practices or even their purchasing plans;
- Local, state, and federal policy and budgetary environments in which schools are working are also in constant flux, making sustained investment and development difficult; and
- Public perceptions of the proper role for new technologies in K-12 education continue to evolve.

Consequently, while we can easily demonstrate that much has been accomplished, it is also clear that much remains to be done and much remains to be learned. In the past ten years, over $40 billion dollars has been spent on upgrading and maintaining the technical infrastructure of America's public schools and training its teachers to use that technology well (Dickard, 2003). We have gone from having little Internet access in schools (35% of schools and 3% of classrooms connected in 1994) to having 99% building-level penetration, and 77% of all classrooms in the country connected to the Internet. The ratio of K-12 students to Internet-connected computers in U.S. public schools dropped from 12-to-1 to 5-1 in only four years (1998-2001) (NCES, 2002). These are undoubtedly major accomplishments. But to describe our progress any further, we must continue to define and evolve our definitions of "high quality use of technology," and, ultimately, we will have to adjust to

seeing schools, like the rest of the major institutions of this country, as institutions in a steady and healthy state of evolution and constant improvement.

WHAT ASSUMPTIONS UNDERLIE OUR VISION FOR HOW TECHNOLOGIES CAN IMPACT TEACHING AND LEARNING?

In our analysis, we considered the underlying vision that has helped to shape how we view the promise and potential of technology in education. What expectations do we have? What do we think technology can deliver? Ultimately, this vision has informed and defined our national conversation about how best to deploy technologies in educational institutions. What we found in examining the literature is that over the past twenty years the education technology community has drawn on three distinct approaches to thinking about and investing in technology. Broadly speaking, these three approaches (described below) have emerged in turn, each responding to and building on the one that came before. However, in individual reports elements of each of these approaches can be found in various combinations, and the three cannot be seen as a clean linear progression.

Investing in Technology to Support Specific and Long Term Needs of Educators

In the one of the earliest reports included in this review, *Power On!* (OTA, 1988), a range of technological tools are viewed as natural matches to broad, ongoing needs within K-12 education, covering both basic skills instruction and the support of higher order thinking skills. For example, the potential benefits of using word processors with students who are developing their writing skills are discussed, as is the anticipated value of using distance learning technologies to support the broader distribution of diverse courses to students in rural areas. The need for clear evidence of impact on student learning is addressed, and the established base of research on learning outcomes associated with using integrated learning systems is summarized, as well as the need for more evidence about the impact of a range of other types of technology. Throughout this report, technologies are seen as a flexible portfolio of tools that, with adequate investment and support, could potentially expand and extend the scope and depth of teachers' teaching.

Finally, *Power On!* identifies four ingredients as being crucial to the successful maturation of education technology as a tool for supporting effective K-12 education: Adequate access to technology, sustained support for educators in learning how to use the technology, further development of educational software, and assurances that research and development work is not only supported but tied closely to the needs and priorities of practitioners. These four elements foreshadow the recommendations made in many of the reports published over the next fifteen years.

Transforming Education Through Technology

In 1995 the tone of these policy reports changes noticeably. In part this is a response to the emergence of the Internet as a major force driving changes in business, civic life and, to some extent, education. During this period, policy reports begin to present education technology as a *driver* of school reform, rather than as a class of tools and resources that, to varying extents, could be matched to educational challenges already recognized by educators. In these reports technology becomes a tool of *transformation*, which promised, simply by its presence and capabilities, to cause changes in how teachers teach, how schools are organized, and how students work together and learn. Reports

representative of this shift in tone include the CEO Forum reports (1999, 2001a, 2001b, and particularly 2000), the report of the Web-based Education Commission (Web-based Education Commission, 2000), and the U.S. Department of Education's overview of technology and education (1997). Notably, two reports produced during this period have quite different tones. The PCAST Panel on Educational Technology report (1997) and the 2000 National Technology Plan both maintain a focus on tying the potential of technology applications to specific relationships between the capacities of the technology tools and particular domains of learning and teaching.

During this period, most reports also begin to present practitioners and their needs and interests in a different light. Rather than being the natural starting point for identifying areas of need and priorities for improving instructional practice, teachers are now framed largely in terms of what they are *lacking*. In the reports of this period education technology becomes a domain described and generally shaped by a research community focused on studying the science of learning and developers who draw on this body of research (this is particularly notable in U.S. Department of Education, 1997, and is also a clear bias of the PCAST report, 1997). The excitement in the research and development community about the potential matches between a transformed educational system, with its material, conceptual, and practical underpinnings reconfigured, and the capacity of various technologies to support significantly different teaching and learning practices, becomes primary to arguments put forth in these reports. See the Web-based Education Commission report (2000) for a clear example of the emphasis placed on "transformative" capacity as a justification for investment.

To the extent that existing conditions of schooling are present in these reports, they are described in terms of their ability to support or impede the effective (i.e., transformative) use of technology (see the CEO Forum reports, the U.S. Department of Education, 2000c summary of survey data on obstacles to technology integration; and, in large part, U.S. Department of Education, 2000b). These "conditions" are, in essence, largely consistent with the areas of needed support described in earlier reports, such as the importance of adequate technical infrastructure, sustained leadership that is supportive of experimentation and provides a vision of effective technology use, and opportunities for sustained and in-depth professional development. However, rather than being a primary object of study for the research community, these conditions are described broadly and consistently throughout this period, and little refinement or increased understanding of their interactions or how they change over time is called for in these reports (note, for example, the consistency between contextual factors identified in *Future Visions* [OTA, 1995a] and in the report on the Secretary's Conference, U.S. Department of Education [2000b]).

What begins to surface in these policy documents is a widening gap between the promise and potential of technology and the ways in which technology actually gains traction in school settings. By 1995, for example, distance learning is being used broadly to disseminate AP and foreign language courses to rural schools, and word processors and digital resources are being used with increasing frequency by teachers of all grade levels in all kinds of schools (OTA, 1995b). But in reports produced soon after this one, these steps are viewed as accommodations of technology into the existing system, and, consequently, as trivial in the face of the radical, transformative potential of technology (U.S. Department of Education, 1996, U.S. Department of Education, 1997). A gap begins to emerge during this period between a relatively rapid but incremental process of innovation and investment occurring in the schools, and a research-driven articulation of technology as a crucial ingredient in the reformulation of the teaching and learning process.

Matching Technologies to Public Priorities for Educational Improvement

In the past three years, as educational priorities have shifted at the national level, the policy voice of the education technology community has shifted as well. A host of influences, both internal and external, have prodded the research and development community to reconsider its relationship to practice, and to revisit the accomplishments of and continued challenges facing practitioners. In part, this reconsideration is a response to evidence suggesting that technology in and of itself does little to drive fundamental improvements in teaching and learning. Even with the comprehensive wiring and build-out of the telecommunications infrastructure in education, teachers continue to work incrementally to appropriate technology, building links step by step between their existing practices and the technological tools available to them. Technological innovations favored by the research community, intended to support inquiry, collaboration, or re-configured relationships among students and teachers continue to be used by only a tiny percentage of America's teachers (Becker, 2001). Instead, teachers are turning to tools like presentation software, resources like student-friendly information sources on the Internet, and management tools like school-wide data systems to support and improve upon their existing practices, while gradually, sometimes, introducing more student-driven or inquiry-oriented technology-rich approaches into their instructional repertories.

These are the real successes of technology in this country's classrooms, and they are not trivial accomplishments. Education technology experts, who have largely been responsible for guiding and informing policymakers' understandings of the potential role of technology in education over the past twenty years, have provided energizing, exciting visions of how technology could potentially "change everything." Recently, however, educational technologists have begun to understand with more nuance that technology needs to work in concert with other factors like effective leadership, instructional priorities, and the day-to-day demands of classroom practice. The most recent policy reports begin to address these needs, and are once again placing technology in the context of broader educational challenges that are of immediate concern to educators and which technology may be well positioned to address, such as the need to make productive use of assessment data; to provide increasingly individualized and flexible but sustained and substantive professional development; and to create administrative efficiencies that support educators in day-to-day work with students and colleagues. These are some of the most promising links between education and technology being recognized and described in the most recent reports reviewed in this paper.

CONCLUSION

Two key themes emerge from this analysis of twenty years of policy recommendations regarding education technology investments. First is the ebb and flow of practitioners' needs and challenges as a guiding force in shaping where and how technology becomes a part of the educational system. Second is the need for a better understanding among both researchers and policymakers of the *systemic* nature of educational change in general and of educational technology integration in particular.

These themes point toward several questions that need to be addressed by the policy, practices, and research communities:

- How can policy be shaped so that technology initiatives can more effectively accommodate and address the issues most relevant to teachers and build on those interests to improve practice over time?

- How can education technology policy best be linked to pressing public concerns regarding education, such as accountability and equity?

- How can we build on past successes, often unheralded, where technology has had a significant impact on a concrete challenge in schooling?

For instance, the steady growth of distance learning, particularly within rural schools, has had a significant impact on what used to be an insurmountable challenge—delivering a broad range of professional development opportunities to rural teachers, and providing rural students with the same diversity of coursework available to students in other settings.

Educational technology has evolved steadily, from the stand-alone computers of the 1980s, to the networked, multimedia workstations of the 1990s, to the highly portable and wireless devices that are beginning to proliferate today. Necessarily, educators' visions of how technology can and should be used have changed as well, in response both to the growing capacities of the technologies and to shifting priorities and needs within the education community. Researchers, in turn, have also gradually evolved their perspective on how to best understand the process of using technological tools to change teaching practices and improve learning outcomes. This change has primarily been one away from single-input models of analysis to an appreciation of the need to address multiple aspects of the educational system when either introducing an intervention or seeking to evaluate its impact on teaching and learning. These "multiple aspects" are well-captured by the seven areas of recommendation discussed above, and researchers, practitioners and policymakers are all increasingly recognizing that these seven issues are not only highly complex within themselves, but are highly inter-related, and that successful solutions will necessarily tackle these issues as an interconnected whole rather than as isolated tasks.

From a policy perspective, the key to making these recommendations actionable has been to identify the points of leverage that cut across multiple areas of need, in order to facilitate strategic progress in the educational technology arena. For example, the massive investments made in

technological infrastructure in the mid-1990s were not only responses to the stated need for improved infrastructure, but were also bids for buy-in from multiple stakeholder communities (consider NetDay, a national initiative to involve communities in developing their schools' technological capacity, see http://www.netday.org/), spurs to further investment in content (consider the increase in web-based content availability that paralleled the increased Internet access in schools), and opportunities for local administrators to develop long-range plans for sustainable technology investment, often in collaboration with the private sector and the local community (spurred in large part by the E-Rate requirement that districts develop technology plans). The close ties among these areas of recommendation make clear that it would be a mistake to expect to reach our goals by simply taking each of the recommendations in isolation. Rather, future policy needs to be crafted to effectively leverage the interaction of these issues and to be informed by clear evidence that documents how "pushing" on one issue can influence the others.

Further, just as technologies themselves have evolved over the past twenty years, so, too, have our goals for student learning, in general, and for the use of technology to support teaching and learning, in particular. As the Partnership for 21st Century Skills notes, "The world in which we live is increasingly sophisticated, multifaceted and nuanced. People need high-level learning skills to act, respond, learn and adjust to ever-changing circumstances. As the world grows increasingly complex, success and prosperity will be linked to people's ability to think, act, adapt and communicate creatively" (2003, p.10).

Undoubtedly, technology shapes, often in unanticipated ways, how we live and work as well as how we educate our children. Consequently, crafting a national roadmap for technology integration in education is no simple task. However, threaded among twenty years of research and policy work on technology's role in education is a conceptual framework for technology's use in education that offers substantial guidance for striking a balance between the demands of improving practice over time and pressing public concerns such as accountability and equity, between the cycle of change in technology and the cycle of change in schools, between the skills of tomorrow and the skills of today. Twenty years ago, the Internet was the stuff of science fiction, but education and government leaders had the foresight to develop a solid foundation on which the future of technology planning would rest. The stage is now set to create a plan that will help us chart the course for education technology for the next twenty years.

REFERENCES

Becker, H.J. (2001, April). *How are teachers using computers in instruction?* Paper presented at the 2001 Meeting of the American Educational Research Association, Seattle, WA. Available online at http://www.crito.uci.edu/tlc/FINDINGS/special3/

The CEO Forum on Education and Technology (1997). *School technology and readiness report: From Pillars to Progress*. Washington, DC: Author. Available online at http://www.ceoforum.org/downloads/

The CEO Forum on Education and Technology (1999). *School technology and readiness report. Professional development: A link to better learning*. Washington, DC: Author. Available online at http://www.ceoforum.org/downloads/99report.pdf

The CEO Forum on Education and Technology (2000). *School technology and readiness report. The power of digital learning: Integrating digital content.* Washington, DC: Author. Available online at http://www.ceoforum.org/downloads/report3.pdf

The CEO Forum on Education and Technology (2001). *School technology and readiness report. Student achievement in the 21st Century Assessment, alignment, accountability, access, analysis.* Washington, DC: Author. Available online at http://www.ceoforum.org/downloads/report4.pdf

The CEO Forum on Education and Technology (2001). *Education technology must be included in comprehensive legislation*. Washington, DC: Author. Available online at http://www.ceoforum.org/downloads/forum3.pdf

Coley, R., Cradler, J., & Engel, P. (1997). *Computers and classrooms: The status of technology in U.S. schools.* Princeton, NJ: Educational Testing Service. Available online at ftp://ftp.ets.org/pub/res/compclss.pdf

Conte, C. (1996). *The learning connection: Schools in the information age.* Report in the What's Going On series. The Benton Foundation, Communications Policy and Practice: Washington, DC. Available online at http://www.benton.org/publibrary/schools/connection.html

Dickard, N. (Ed.) (2003). *The sustainability challenge: Taking ed-tech to the next level.* Washington, DC: The Benton Foundation Communications Policy Program & EDC Center for Children and Technology. Available online at http://www.benton.org/publibrary/sustainability/sus_challenge.html

Education Commission of the States (2001). *Investing in K-12 technology equipment: strategies for state policymakers*. Denver, CO: Author. Available online at http://www.ecs.org/clearinghouse/23/39/2339.htm

Elementary and Secondary Education Act (ESEA). (2001). *No Child Left Behind Act of 2001*. Available online at http://www.ed.gov/policy/elsec/leg/esea02/index.html

McKinsey and Company (1995). *Connecting K-12 schools to the information superhighway*, New York: Author. Available online at http://cavern.uark.edu/mckinsey/

National Association of State Boards of Education. (2001). *Any time, any place, any path, any pace: Taking the lead on e-learning policy*. Alexandria, VA: Author. Available online at http://www.nasbe.org/e_Learning.html

National Commission on Excellence in Education. (April, 1983). *A nation at risk*. Available online at http://www.ed.gov/pubs/NatAtRisk/risk.html

National Information Infrastructure Advisory Council (NIIAC) (1996). *Kickstart initiative: Connecting America's communities to the information superhighway*. Available online at: http://www.benton.org/publibrary/kickstart/kick.home.html

Office of Educational Research and Improvement, U.S. Department of Education, (2000). *Teachers' tools for the 21st century: A report on teachers' use of technology*. Washington, DC: Author. Available online at http://nces.ed.gov/pubs2000/2000102.pdf

Office of Technology Assessment (1988). *Power on! New tools for teaching and learning* (OTA-SET-379). Washington, DC: US Government Printing Office. Available online at http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk2/1988/8831/8831.PDF

Office of Technology Assessment (1989). *Linking for learning: A new course for education* (OTA-SET-430). Washington, DC: U.S. Government Printing Office. Available online at http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk1/1989/8921/8921.PDF

Office of Technology Assessment (1992). *Testing in American schools: Asking the right questions* (OTA-SET-519). Washington, DC: U.S. Government Printing Office. Available online at http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk1/1992/9236/9236.PDF

Office of Technology Assessment (1993). *Adult literacy and new technologies: Tools for a lifetime* (OTA-SET-550). Washington, DC: U.S. Government Printing Office. Available online at http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk1/1993/9303/9303.PDF

Office of Technology Assessment (1995a). *Education and technology: future visions* (OTA-BP-HER-169). Washington, DC: U.S. Government Printing Office. Available online at http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk1/1995/9522/9522.PDF

Office of Technology Assessment, (1995b). *Teachers and technology: Making the connection* (OTA-HER-616). Washington, DC: U.S. Government Printing Office. Available online at http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk1/1995/9541/9541.PDF

Partnership for 21st Century Skills. (2003). *Learning for the 21st century.* Washington, D.C.: Author Available online at http://www.21stcenturyskills.org

Pearson, G., & Young, A. T. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: National Academy Press. Available online at http://www.nap.edu/catalog/10250.html

President's Committee of Advisors on Science and Technology, Panel on Educational Technology (1997). *Report to the president on the use of technology to strengthen K-12 education in the United States*. Washington, DC: Author. Available online at http://www.ostp.gov/PCAST/k-12ed.html

U.S. Department of Commerce, Technology Administration (2002). *Visions 2020: Transforming education and training through advanced technologies*. Washington, DC: Author. Available online at http://www.technology.gov/reports/TechPolicy/2020Visions.pdf

U.S. Department of Commerce, Economics and Statistics Administration, National Telecommunications and Information Administration. (2002). *A nation online: How Americans are expanding their use of the Internet*. Available online at http://www.ntia.doc.gov/ntiahome/dn

U.S. Department of Education (1996). *Getting America's students ready for the 21st century: Meeting the technology literacy challenge: A report to the nation on technology and education*. Washington, DC: Author. Available online at http://www.ed.gov/about/offices/list/os/technology/plan/national/index.html

U.S. Department of Education (1997). *Overview of technology and education reform*. Washington, DC: Author. Available online at http://www.ed.gov/pubs/EdReformStudies/EdTech/overview.html

U.S. Department of Education (2000a). *The national technology education plan. e-Learning: Putting a world-class education at the fingertips of all children*. Washington, DC: U.S. Government Printing Office. Available online at http://www.ed.gov/about/offices/list/os/technology/reports/e-learning.pdf

U.S. Department of Education (2000b). *The secretary's conference on educational technology: Measuring impacts and shaping the future*. Washington, DC: Author. Available online at http://www.ed.gov/rschstat/eval/tech/techconf00/report.html

U.S. Department of Education, National Center for Education Statistics (2000c). *Teachers' Tools for the 21st Century: A Report on Teachers' Use of Technology*. NCES 2000–102. Washington, DC: Author. Available online at http://nces.ed.gov/surveys/frss/publications/2000102/index.asp

U.S. Department of Education, National Center for Education Statistics (September, 2002). *Internet access in U.S. public schools and classrooms: 1994-2001*. Available online at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2002018

Web-based Education Commission (2000). *The web-based education commission, The power of the Internet for learning: Moving from promise to practice*. Washington, DC: U.S. Government Printing Office. Available online at http://www.ed.gov/offices/AC/WBEC/FinalReport/WBECReport.pdf

Withrow, F. (2001). *A brief history of technology at the federal level*. Available at http://www.usdla.org/html/journal/JUN01_Issue/article05.html