Teachers and Technology: Making the Connection

April 1995

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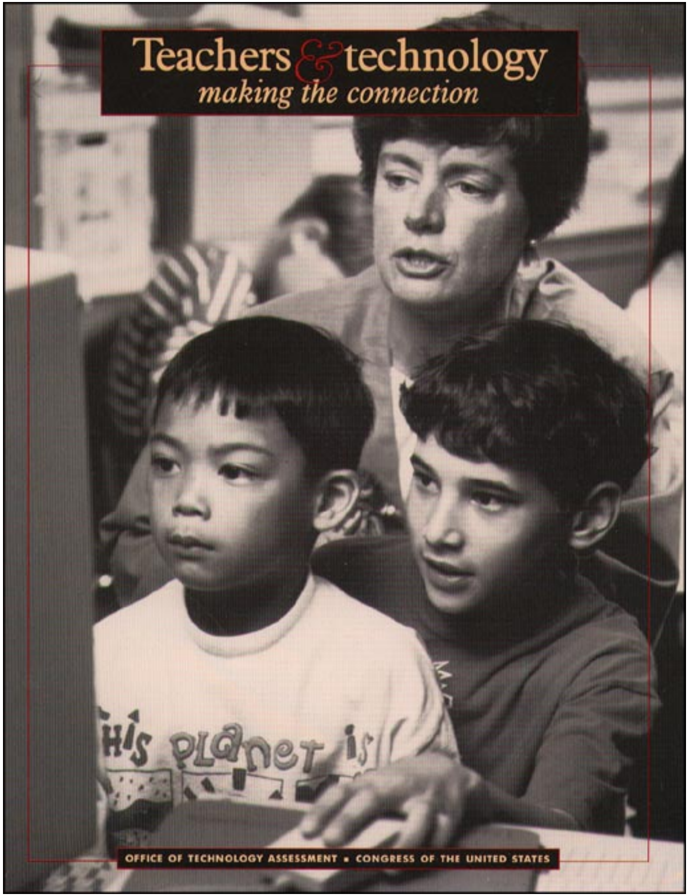

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Foreword

In the United States, the public school system is designed—ideally—to produce effective, thoughtful citizens who will become valuable contributors to society. In the race to make sure our students are well prepared to handle the world they walk into when they walk out of schools, the nation has tried to enlist as teaching resources the most relevant technological innovations of our time—whether television or telecommunications, calculators or computers. But in the process of equipping our students to learn with technology, a valuable—perhaps the *most* valuable—part of the education equation has been virtually overlooked: the teachers.

Despite over a decade of investment in educational hardware and software, relatively few of the nation's 2.8 million teachers use technology in their teaching. What are some of the reasons teachers do not use technology? What happens when they do use technology? What factors influence technology integration in schools? What roles do schools, districts, states, the private sector, and the federal government play in helping teachers with new technologies? OTA's in-depth examination of these questions was initiated at the request of the Senate Committee on Labor and Human Resources, and endorsed by the House Committee on Education and Labor (now the House Committee on Economic and Educational Opportunities) and a member of the Senate Appropriations Committee. As this report will show, helping schools to make the connection between teachers and technology may be one of the most important steps to making the most of past, present, and future investments in educational technology and in our children's future.

Throughout this study, the advisory panel, workshop participants, and many others played key roles in defining major issues, providing information, and contributing a broad range of perspectives that helped shape this report. OTA thanks them for their substantial commitment of time and energy. Their participation does not necessarily represent an endorsement of the contents of the report, for which OTA bears sole responsibility.

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OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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Summary and Policy Options 1

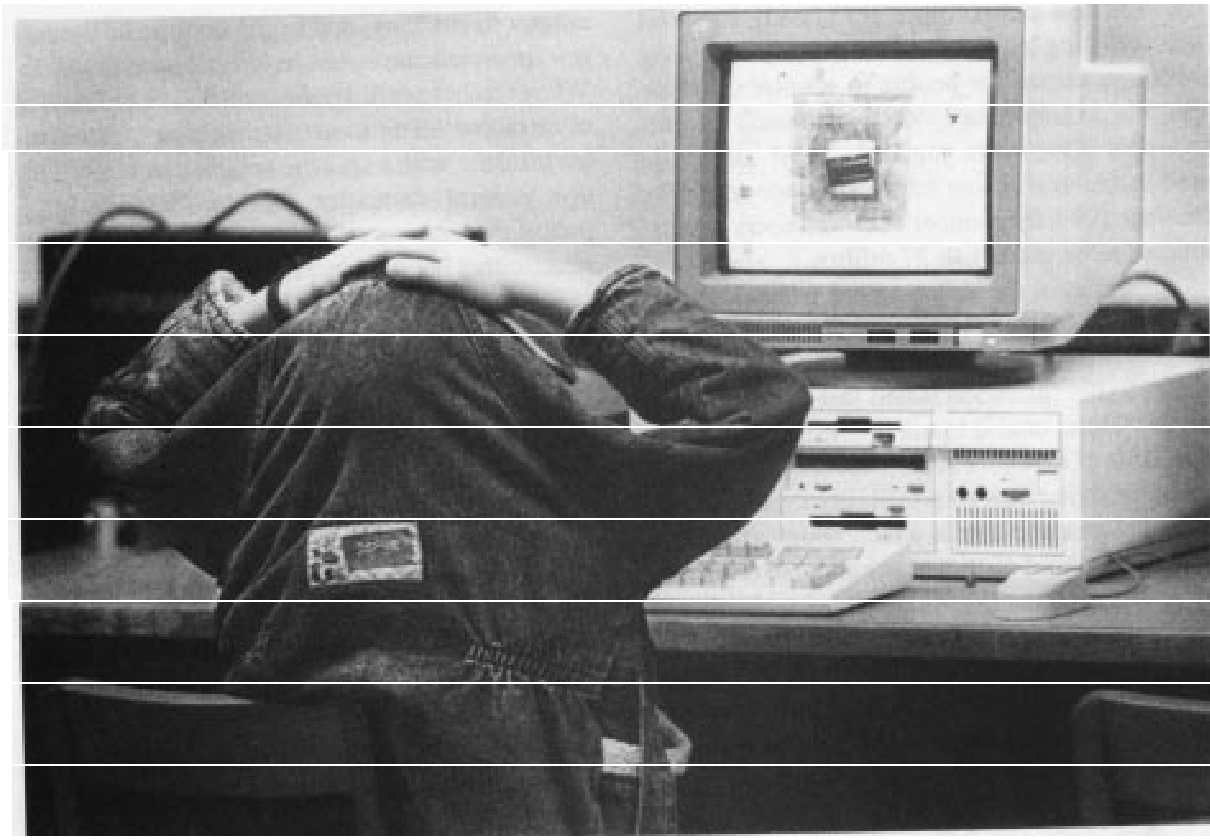
SUMMARY OF KEY FINDINGS

- Projections suggest that by spring 1995, schools in the United States will have 5.8 million computers for use in instruction—about one for every nine students. Almost every school in the country has at least one television and videocassette recorder, and 41 percent of teachers have a TV in their classrooms. Only one teacher in eight has a telephone in class and less than 1 percent have access to voice mail. Classroom access to newer technologies like CD-ROM and networking capabilities are also limited. While 75 percent of public schools have access to some kind of computer network, and 35 percent of public schools have access to the Internet, only 3 percent of instructional rooms (classrooms, labs, and media centers) are connected to the Internet.
- Despite technologies available in schools, a substantial number of teachers report little or no use of computers for instruction. Their use of other technologies also varies considerably.
- While technology is not a panacea for all educational ills, today's technologies are essential tools of the teaching trade. To use these tools well, teachers need visions of the technologies' potential, opportunities to apply them, training and just-in-time support, and time to experiment. Only then can teachers be informed and fearless in their use of new technologies.
- Using technology can change the way teachers teach. Some teachers use technology in traditional "teacher-centered" ways, such as drill and practice for mastery of basic skills, or to supplement teacher-controlled activities. On the other hand, some teachers use technology to support more student-centered approaches to instruction, so that students can conduct

Helping teachers become "fearless" with technology could be the best way to assure that they use these tools effectively in their classrooms.

their own scientific inquiries and engage in collaborative activities while the teacher assumes the role of facilitator or coach. Teachers who fall into the latter group are among the most enthusiastic technology users, because technology is particularly suited to support this kind of instruction.

- Increased communications is one of the biggest changes technology offers classroom teachers. Telecommunications, from simple telephones to advanced networks, can transcend the walls of isolation that shape the teaching profession and allow teachers to converse and share experiences with colleagues, school administrators, parents, and experts in the field.
- Helping teachers use technology effectively may be the most important step to assuring that current and future investments in technology are realized.
- Most teachers have not had adequate training to prepare them to use technology effectively in teaching. Currently, most funds for technology are spent on hardware and software, but experienced technology-using sites advocate larger allocations for training and support. On average, districts devote no more than 15 percent of technology budgets to teacher training. Some states have suggested this figure should be more like 30 percent.
- A majority of teachers report feeling inadequately trained to use technology resources, particularly computer-based technologies. Although many teachers see the value of *students* learning about computers and other technologies, some are not aware of the resources technology can offer them as professionals in carrying out the many aspects of their jobs.
- Although schools have made significant progress in helping teachers to use basic technological tools such as word processing and databases, they still struggle with integrating technology into the curriculum. Curriculum integration is central if technology is to become a truly effective educational resource, yet integration is a difficult, time-consuming, and resource-intensive endeavor.
- Technology can be a valuable resource for improving teacher education overall. It can bring models of the best teaching live from the classroom into the colleges of education, or provide video case studies of teaching styles and approaches. It can forge stronger connections among student teachers, mentor teachers in the field, and university faculty.
- Despite the importance of technology in teacher education, it is not central to the teacher preparation experience in most colleges of education in the United States today. Most new teachers graduate from teacher preparation institutions with limited knowledge of the ways technology can be used in their professional practice.
- The federal government has played a limited role in technology-related teacher development compared with states, universities, and school districts. Even so, past federal programs have piloted innovative educational applications of technology for teachers by providing significant support for professional development, specifically among mathematics, science, and special education teachers, and by providing funding for technology-related professional



CHRIS HARDY, SAN FRANCISCO EXAMINER

Technology is a fact of life in today's society and students will need to be facile with these powerful tools. This young student makes sure his thinking cap is on as he ponders a computer screen in the classroom.

development in school districts that could not have supported it on their own.

- The federal government has tended to focus more on inservice than preservice education, channeling more support to K-12 schools than to colleges of education—an approach that may address current needs but does not greatly influence teacher preparation or quality over the long term.
- The federal government has a unique opportunity to encourage greater links between technology and professional development, through recent legislation such as Goals 2000 and the Improving American's Schools Act. The way the laws are currently written, however, funding for technology and teacher training, and support for effective use, may not be high priorities. National leadership for educational technology can create enthusiasm and support for state and local technology initiatives. Focusing attention, as well as funding, on how technologies can support professional development, and on how teachers are essential to the implementation of technologies, can send important signals to schools around the country.

INTRODUCTION

"A teacher affects eternity; he can never tell where his influence stops."

Henry Adams, from The Education of *HenryAdams*

Technology is a fact of American life. Computers, video, television, telephones, radio, and telecommunications networks exert an incalculable influence on how we live, work, and play—an influence likely to expand as hardware and software become more powerful, affordable, and pervasive.[1] New technologies are already essential tools for doing business and are quickly becoming a primary means for people to acquire information. For example, in 1993 an estimated 12 million-plus Americans regularly used electronic mail and related online information services.[2] By October 1994, the number of e-mail users was estimated to be more than 27 million.[3]

For students, the ability to use technology has come to be recognized as an indispensable skill. The Secretary's Commission on Achieving Necessary Skills (SCANS) stated this in the starkest terms, "Those unable to use . . . [technology] face a lifetime of menial work."[4]

Recognizing their responsibility to prepare students to work and live in a technological society, states and school districts have adopted standards for teaching students with and about technology.[5] For example, in a 1994 survey conducted for the Office of Technology Assessment (OTA), all but seven states reported that they require or recommend integrating computers or information technology into the curriculum, and 19 states require seniors to demonstrate computer competency before graduating.[6] The question now is, how can schools use technology more effectively?

Most policy discussions and technology initiatives have tended to focus on hardware and software acquisition, and student access to technology. However, in the enthusiasm to get technology to students, and in the context of limited resources, teacher issues have been shortchanged. When teacher needs are discussed, the emphasis is often on providing short-term training to familiarize teachers with a specific application or encourage general computer literacy. Seldom have policy discussions or initiatives centered on the relationship between technology and the teacher's role. Seldom have they articulated a vision of how technology can empower teachers to carry out all parts of their jobs.

In response to these concerns, noted as issues in earlier OTA reports,[7] OTA was asked to do this study by congressional committees and members of Congress with interests in the application of emerging technologies to education (see box 1-1).

In addition to the usual OTA process of convening an advisory panel, conducting extensive staff work, and obtaining broad peer review of drafts, OTA used a variety of methods to conduct this assessment (see box 1-2). The technologies OTA focused on and their current availability in the nation's elementary and secondary schools are described in box 1-3.

OTA finds the lack of attention to teachers and technologies ironic, for at the center of effective use of instructional technologies are those who oversee the daily activities of the classroom—the teachers. **To use new technologies well, teachers**

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[1] See, e.g., U.S. Congress, Office of Technology Assessment, *Electronic Enterprises: Looking to the Future*, OTA-TCT-600 (Washington, DC: U.S. Government Printing Office, May 1994).

[2] J. Eckhouse, "Internet: Millions of Users Plug in to Hug Computer Network," *San Francisco Chronicle*, June 1, 1993, pp. C-1, C-7.

[3] Matrix Information and Directory Services, Austin, TX, October 1994.

[4] *What Work Requires of Schools: A SCANS Report for America 2000*, Secretary's Commission on Achieving Necessary Skills (Washington DC: U.S. Department of Labor, June 1991), p. 15.

[5] For this study, when the term *technology* is used, it refers to all forms of computers and their peripherals including hard disk drives, printers, CD-ROM, projection devices, and networks offering telecommunications linkages. It also refers to a range of other new or more traditional technologies: telephones, video cameras, televisions and VCRs, fax machines, videodiscs, cable and other one- or two-way links, small devices like electronic calculators, personal digital assistants or other hand-held devices, or combinations of these and other new technologies.

[6] Ronald E. Anderson, "State Technology Activities Related to Teachers," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, Nov. 15, 1994.

[7] U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988); and *Linking for Learning: A New Course for Education*, OTA-SET-430 (Washington, DC: U.S. Government Printing Office, November 1989).

BOX 1-1: Why This Study?

In 1986, Congress asked the Office of Technology Assessment to study the use of computers in schools, In 1988, OTA reported its findings in *Power On! New Tools for Teaching and Learning,*[1] which described the promise of and barriers to using technology in K-12 education. At that time, there were about two million personal computers in American schools, a ratio of roughly one computer for every 30 students. Most educational software was limited to drill-and-practice applications. A handful of small, special-purpose educational software publishers were scrambling to create a market for their products. Schools were focusing attention on teaching students "computer literacy" skills. Teacher training consisted of general computer awareness courses, and a few adventurous souls were learning to program in BASIC or LOGO, so they could design their own software applications. At that time, most teachers did not use computers as a significant part of their teaching-only half the K-12 teaching force reported using computers in instruction. Few teachers had computers of their own at school or at home. Not surprisingly, many teachers were less than impressed with this new wave of educational euphoria.

Similarly, in 1989 when OTA released *Linking for Learning: A New Course for Education,*[3] a followup report assessing how schools were using distance-learning technologies to link students and teachers with resources, activity was limited. At that time, states were beginning to invest in broadcast, microwave, satellite, cable, and computer-based systems, and the federal Star School Project had just funded its first round of projects. In subsequent work assessing technologies for testing[4] and adult literacy,[5] OTA reported on emerging opportunities presented by technology.

In each of these reports to Congress OTA noted the critical role of teachers. To learn more about how schools and teachers use computers and other technologies and what this means for future policies, in the summer of 1993 Congress requested OTA to revisit the issue of teachers and technology in K-12 schools in depth.

Requesters, and their affiliations during the 103d Congress are as follows:

U.S. Senate

Committee on Labor and Human Resources
Edward M. Kennedy, Chairman[6]
Committee on Appropriations
Thad Cochran, Member

U.S. House of Representatives

Committee on Education and Labor[7]
Williarn D. Ford, Chairman[8]
William F. Goodling, Ranking Minority Member[9]
Subcommittee on Elementary, Secondary, and Vocational Education[10]
Dale E. Kildee, Chairman[11]

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[1] U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning,* OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988).

[2] The main focus of that report was the personal computer, whether as a stand-alone unit, connected to a local area network or as part of a more comprehensive integrated learning system.

[3] *Linking for Learning: A New Course for Education,* OTA-SET-430 Washington, DC: U.S. Government printing Off Ice, November 1989).

[4] *Testing in American Schools Asking the Right Questions,* OTA-SET-519 (Washington, DC: U.S. Government Printing Office, February 1992),

[5] *Adult Literature and New Technologies: Tools for A Lifetime,* OTA-SET-550 (Washington, DC: U.S. Government Printing Office, July 1 993),

[6] Now Ranking Minority Member.

[7] Now the House Committee on Economic and Educational Opportunities.

[8] Now retired,

[9] Now Chairman, House Committee on Economic and Educational Opportunities.

[10] Now the House Subcommittee on Early Childhood, Youth, and Farnilies.

[11] Now Ranking Minority Member.

(continued)

BOX 1-1 (cont'd.): Why This Study?

The requesters asked OTA to look at several issues, Do teachers use technology in their teaching? Why? What happens when they do? Why don't more teachers use technology? How do teachers learn about technology? Are prospective teachers being prepared to use technology before entering the classroom? Which factors influence implementation of technology across schools and districts? What roles do schools, districts, states, and the federal government play in helping teachers adjust to the challenges and opportunities presented by new technologies? This report describes the results of OTA's research into all of these questions.

The issue of teachers and technology is of continuing relevance to the 104th Congress. Two major pieces of legislation passed in the 103d Congress have provided authorization for a number of initiatives related to technology. The decisions made by the 104th Congress will shape the direction of these initiatives. The Goals 2000: Educate America Act encourages states to undertake ambitious school reform efforts and funds statewide plans for using technology to achieve these reforms. The Improving America's Schools Act, in a revised Title III of the Elementary and Secondary Education Act (ESEA), contains the most comprehensive legislation for educational technology ever passed by Congress and places a greater emphasis on teacher professional development in several other federal programs. These two laws have the potential to bring more coherent and consistent leadership to the federal role in technology and teacher development, but whether this occurs will depend on how the programs are funded and implemented. This report contains discussion of issues and policy options relevant to implementation.

In addition to funding decisions about current education programs, the 104th Congress faces other issues affecting education technology, most notably legislation to update the Communications Act of 1934. The availability and affordability of telecommunications technologies for schools are two of the most important issues affecting the future of educational technology.

not only need access to them, but they also need opportunities to discover what the technologies can do, learn how to operate them, and experiment with ways to apply them For teachers to make informed choices and wise uses of technology, they must be literate and comfortable with a range of educational technologies.

However, the use of technology in teaching, like any other change to the status quo, should be considered in light of the unique characteristics of the teaching profession. Indeed, teaching has been called many things: an art, a science, a calling, a way of life. Throughout history, teachers have taken up the tools at hand to help them teach—whether marking on clay with a stylus, or writing on a blackboard with chalk. As new technologies have emerged—photography, filmstrips, radio, television—teachers have used them to extend the range of what they could teach, illustrate ideas in different ways, bring new materials to students, and motivate learners.

The process of adopting new technologies has never been quick or effortless, however. Like all professionals, teachers have instructional methods, teaching styles, and working procedures that have served well in the past and that often reflect how they themselves were prepared. And like other large institutions, schools have organizational characteristics that make change difficult. Moreover, the unique culture of schools and changing public expectations for them create conditions substantially different from those of other workplaces.

Although teachers want to enlist all available tools to help their students learn, as new technologies have become more sophisticated, the transition has become even harder, requiring more training before teachers can use them effectively. Teachers, like many in society, can find themselves bewildered by the changing landscape of computer, video, and telecommunications technologies. Many are made skeptical by predictions

BOX 1-2: How This Study Was Cond

Although considerable research has been conducted since 1988 on student uses of technology, far less has been done on teacher uses, and consequently data on teacher issues are limited. As a starting point for this study, OTA reviewed research on teachers and technology, including national surveys and studies, evaluations of federal technology-related programs, and research on state, district, and school technology efforts.

During the course of this study, OTA staff made site visits to schools of all grade levels across the country (see appendix E), and had hundreds of conversations with teachers, researchers, and administrators—in classrooms, at meetings and conferences, and over the telephone and electronic mail. OTA also convened two focus groups of teachers and held a workshop about lessons from research projects on technology in schools.

OTA also drew upon a range of other sources. Much of the background information for the study came from research contracted by OTA (see appendix F), including a series of in-depth interviews with average teachers regarding their experiences with technology,[1] a survey of faculty and recent graduates of colleges of education regarding technology use in preservice teacher education,[2] a research review of telecommunications networks,[3] and a review of past and current federal programs and support for teacher development and technology.[4] A series of OTA-contracted case studies looked at exemplary approaches to training teachers about technology use at the preservice and inservice level.[5] OTA contracted for two other research reviews: an analysis of trend data from several surveys about school acquisition and use of new technologies,[6] and a review of state policies related to technology in K-12 education.[7]

Some of these research strategies yielded statistical data. Others produced information that was mostly descriptive or anecdotal on such issues as teachers' perceptions of the role of technology in their teaching and the factors that encourage or inhibit their technology use. By combining quantitative and qualitative information, OTA has tried to present a multifaceted picture of teacher experiences with technology.

As with all OTA reports, the project was guided by an advisory panel made up of experts and stakeholders in the field: teachers, principals, and district, state, and school board personnel; college of education faculty; representatives of teacher unions and professional organizations; hardware, software, and business representatives; and telecommunications and media experts. The advisory panel met twice, at the beginning of and near the end of the research phase of the project, and helped define the research questions and interpret the information. In addition, dozens of individuals reviewed drafts of and contributed to this study (see appendix D). Although every panel member and reviewer may not agree with all the findings or policy options in this report, the panel's and other reviewers' guidance and direction were critical in shaping its final form.

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[1] Melinda Griffith, "Technology in Schools: Hearing from the Teachers, " Office of Technology Assessment, contractor report, October 1993.

[2] Jery Willis et al., "Information Technologies in Teacher Education Survey of the Current Status, " Office of Technology Assessment, contractor report, March 1994.

[3] TERC, "Review of Research on Teachers and Telecommunications, " Office of Technology Assessment, contractor report, May 1994,

[4] Nancy Kober, "Teachers and Technology: The Federal Role, " Office of Technology Assessment, contractor report, May 25,1994.

[5] John R. Mergendoller et al., "Case Studies of Exemplary Approaches to Training Teachers to use Technology, " Office Of Technology Assessment, contractor report, May 1994.

[6] Henry J. Becker, "Analysis and Trends of School Use of New Technologies," Office of Technology Assessment, contractor report, March 1994

[7] Ronald E. Anderson, "State Technology Activities Related to Teachers, " Office of Technology Assessment, contractor report, Nov. 15, 1994.

promising that new technologies will reform education and change schools as we know them.

Making the connection between technology and teachers—helping the 2.8 million teachers in public and private kindergarten-through-twelfth-grade (K-12) schools effectively incorporate technology into the teaching and learning process—is one of the most important steps the nation can take to make the most of past and continuing investments in educational technology. It is central to the ultimate goal fostered by these investments: not just helping students become competent users of technology, but helping them become more accomplished learners overall.

This report seeks to underscore the connection between teachers and effective implementation of technology in schools.

TEACHING AND TECHNOLOGY: THE POTENTIAL

"You wouldn't want a doctor to remove your gall bladder without the latest technology and the skill to use that technology, would you? It's the same with teaching. [Teachers need tools, skills]. . .it's a profession."

Rusty Sweeny, algebra teacher, Piscataquis Community High School, Guilford, ME

OTA has seen the promise of technology come to light in school districts throughout the country, where many teachers are using technology to teach their students. Some have found it to be a catalyst to support school reform, stimulate new teaching methods, and even redefine the role of teachers. But it is not only in the realm of direct student contact that technology has benefited these teachers. Many other aspects of a teacher's job—preparing materials, developing lessons, assessing student progress, enlisting parent participation, keeping up with advances in pedagogy and content, and participating in the professional community—can be accomplished with technology, often more easily and efficiently. When teachers discover ways that technology can strengthen their teaching, help them carry out administrative tasks, and enrich their professional growth, technology starts to make sense to them. It can be a resource for improving the preparation of new teachers as well. However, there are also many teachers who have not seen this potential, teachers whose use of technology is marginal, limited, and unenthusiastic. The stories and experiences of both these groups suggest lessons for policymakers. Table 1-1 summarizes the potential that technology offers to schools and teachers.

Improving Teaching with Technology

OTA has found many examples throughout the nation of how technology can help teachers with all parts of their jobs. First and foremost, teachers want to ensure that their students are learning. If technology can be a resource to enhance student achievement and interest in learning, teachers are more likely to invest the time and energy to learn to use it in their teaching. However, the relationship between technology and student learning is too often framed as a seemingly simple question: is teaching with computers and other technologies better than teaching without them? Clearly, computers "cannot change leaden instruction into gold,"[8] and there remain numerous questions about how, when, and how well alternative technologies contribute to student learning and achievement. Issues related to measuring the impact of various approaches to teaching, including the use of new technologies on student learning are complicated and beyond the scope of this study (see box 1-4). This report's analysis of the potential of technologies for improving teaching and learning focuses on two aspects of the teaching-learning continuum: teachers' perceptions of how new technologies help them improve their instruction and how they see their classrooms changing as a result.

Many technology-using teachers find that technology can help them improve student learn-

[8] James Bosco, Western Michigan University, personal communication, August 1993.

BOX 1-3: Technologies in U.S. Schools: Definitions and Availability

What are the technologies available in U.S. schools today and how are they used? Following is a brief outline of some technologies found in schools and the potential impact of those technologies on teachers and students.

Computers

A computer is a programmable, electronic machine that can store, retrieve, and process data. Desktop computers are sometimes called microcomputers because they have a single integrated circuit known as a microprocessor.

During the last three years, the total number of computers in schools has risen by about 18 percent annually and, based on those projections, there will be an estimated 5.8 million computers in U.S. schools by spring 1995. That translates to approximately one computer for every nine students. There is enormous variability in student-computer ratios *(computer density)* from school to school and across states. The greatest disparities are found between small schools (enrollments of 300 or less) and large schools (enrollments of 1,000 or more); schools with fewer students tend to have more computers per student.

Still, sheer numbers of computers do not indicate real access or use. For example, although 35 percent of all U.S. public schools have access to the Internet, only 3 percent of instructional rooms (classrooms, labs, and media centers) are connected. Many factors dictate technology use, but the age and power of the technology seems to be a prevalent influence in K-12 schools. As of 1992, one-half of the computers used for K-1 2 instruction in the United States were older, less-powerful Apple II models, yet most software and applications currently being developed today cannot run on these machines.

Two-Way Communications

Two-way communications that allow teachers and students to share and receive ideas with others outside their immediate classroom are an important aspect of telecommunications networking. For basic two-way communications, telephones and *modems* are staple equipment. Currently, though, only one teacher in eight has a telephone in the classroom that can be used for outside calls. In addition, less than 1 percent of teachers with telephones have access to voice mail, which is a useful tool to leave or retrieve messages when parents, administrators, or other teachers are hard to reach during the school day.

A *modem* is a device that allows computers to communicate electronically across telephone lines by converting digital computer signals into analog format for transmission. In recent years, schools have begun installing more modems for teacher use: in 1989 one-fourth of U.S. schools had a modem that could be used by teachers or students, and by 1992 the figure had grown to 38 percent of all schools, although more high schools (60 percent) had modems than middle schools (35 percent) or elementary schools (33 percent).

Telecommunications Networking

Telecommunications networking includes the Internet and other means of accessing shared communications systems that support digital communications among connected computers.

Local area networks (LAN) link computers and peripherals (e.g. printers) within a limited area, often a classroom or building. Wide *area networks (WANS)* connect computers over greater distances, such as building to building, city to city, and so on. Overall, 75 percent of public schools have computers with some networking capabilities-either LAN or WAN access—and of those schools, 40 percent report that machines with these capabilities are located in classrooms;[1] 71 percent say they are located in administra-

1 Many schools responding to the survey reported access in more than one location. U.S. Department of Education, *Advanced Telecommunications in U.S. Public Schools,* K-12 (Washington, DC, U S Department of Education, OERI, February 1995), NCES 95-731,

(continued)

BOX 1-3 (cont'd.): Technologies in U.S. Schools: Definitions and Availability

tive offices; 62 percent, in library/media centers; and only 15 percent in teacher workrooms. Electronic mail (e-mail) is the most common use of telecommunications reported by teachers who are accomplished telecommunications users.[2]

The Internet

The Internet is an international collection of interconnected electronic networks and a set of protocols for communication between computers on these networks. The protocols also include a large and growing list of services that can be provided or accessed over the Internet.

Of the schools reporting networking capabilities, 49 percent have WANS; 35 percent of those have access to the Internet, and 14 percent have access to other types of wide area networks, such as America Online, CompuServe, or Prodigy. Of those with Internet access, on average, only 3 percent of schools have access in instructional rooms (classrooms, library/media centers, computer labs). This means students and teachers typically do not have access to Internet services.

Television/Video

Nearly every school in the country has at least one television set for instructional use. Video is the most common technology used for instruction in schools, from sources such as direct broadcast and cable television and satellite (distance learning). As of 1991, the typical school had seven television sets and six videocassette recorders, which teachers typically use to record and show students commercially broadcast educational programs. While the use of more interactive video resources, such as camcorders, videodiscs, and CD-ROM is growing, these are not used with as much frequency in schools.

Broadcast television (national networks, such as NBC, CBS, ABC) is received by 70 percent of all public schools (61 percent of schools receive PBS). Eighty-three percent of those schools report that broadcast access is available in classrooms, and 84 percent report access in the library/media center.

Cable television (subscription television, such as CNN, the Discovery Channel, The Learning Channel) is available in 74 percent of all public schools, and 70 percent of those schools say access is available in classrooms, while 85 percent report access in library/media centers.

Closed-circuit television (neither broadcast nor cable, but in-house transmission on noncommercial lines) is only available in 25 percent of schools, but 94 percent of those schools say classrooms have access, and 89 percent report access to closed circuit TV in library/media centers.

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[2]Margaret Honey and Andres Henriquez, *Telecommunications and K-12 Educators, Findings From A National Survey (New 'fork:* Center for Technology in Education, Bank Street College of Education, 1993).

SOURCE: Office of Technology Assessment, 1995, based on Henry J. Becker, "Analysis and Trends in School Use of New Technologies, " Office of Technology contractor report, March 1994; *also, Advanced Telecommunications in U.S. Public Schools, K-72,* National Center for Education Statistics NCES95-731 (Washington, DC: U.S. Department of Education, OERI, February 1995), see also chapter 3 of this report.

ing and motivation, address students with different learning styles or special needs, expose students to a wider world of information and experts, and implement new teaching techniques. There are many examples of how technology has enhanced teaching:

- Students engaged in a group problem-solving project based on a software or video simulation are learning to work as a team, develop expertise in specific areas, become more confident learners, and weigh the merits of several possible solutions.

- Teachers involved in an international telecommunications project find their students acquiring a new interest in geography, and bonding with students across the globe or in the different world that exists even on the other side of town.
- With graphing software, students appear to develop a deeper understanding of mathematical concepts for which they had learned the formulas but had not applied consistently.
- Special education students, mainstreamed into regular classrooms, work on a more equal basis with their classmates when a computer speaks for them, gives them big print, or adjusts to their difficulties.
- Students who were on the verge of dropping out take anew interest in school when, as part of a class project, they interview other students with camcorders and create daily news shows.
- Using CD-ROM, students research a multimedia term paper, evaluating resources from print, video, and audio media.
- After the teacher downloads satellite pictures of daily weather patterns, students use a network to compare their weather data with weather data reported by students around the country, analyzing trends and predicting likely conditions.
- A scientist working on cancer research can come online and advise a student setting up a science project on molecular biology.

Teachers find that using technology can encourage students to take more responsibility for their learning, to learn to work cooperatively, and gain experience in acquiring, evaluating, and using information in various forms.

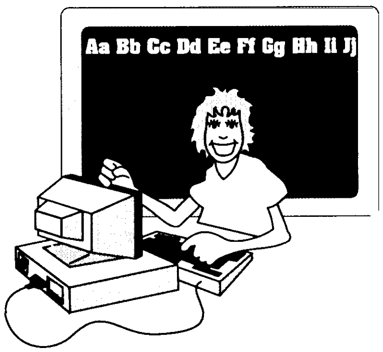
These kinds of experiences, while far from the norm in schools today, can and do occur in classrooms with access to technology and a teacher who can skillfully guide its use. In most of the above examples, teachers find that their students are doing more than learning generic technology skills or subject-specific technology applications. Rather, they see them developing the kinds of skills and competencies that numerous reform panels have encouraged as essential for all high school graduates-problem-solving skills; broader scientific literacy and mathematical understanding; strong communication skills; personal responsibility, integrity, and initiative; and skills and competencies for the workplace. These workplace competencies include working with resources, acquiring and evaluating information, working with others in groups or teams, understanding complex relationships and systems, and using a range of changing technologies.[9] Although these skills can be developed without technology, technological tools can help teachers structure, organize, or enhance the activities that facilitate the development of these skills.

Accomplished technology-using teachers indicate that using computers has changed their teach-

[9] See, e.g. Secretary's Commission on Achieving Necessary Skills, op. cit. footnote 4; Anthony Patrick Carnevale, *America and the New Economy* (Washington, DC: American Society for Training and Development, 1991); and William B. Johnston and Arnold H. Packer, *Workforce 2000* (Indianapolis, IN: Hudson Institute, June 1987).

TABLE 1-1: Teaching and Technology: The Potential

Changing teaching and learning



- *Resources for teaching* abstract concepts, complex systems, problem solving—and basic skills
- *Resources for group work and collaborative inquiry*
- *Adaptable* to various student learning styles and special needs
- *Teachers report they:*

—Expect more of students

—Are more comfortable with students working independently

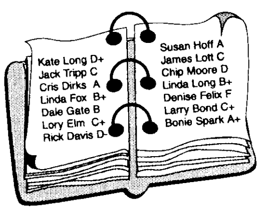
—Present more complex materials

—Tailor instruction more to individual needs

—Adopt new roles, more '(guide on the side" than "sage on the stage"

—Spend less time lecturing, so classrooms are more student-centered

Assisting with daily tasks

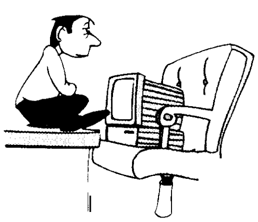


- *Preparing lesson plans*
  Online databases, CD-ROMs, videodiscs, and other electronic sources help teachers create, customize, and update lessons.
- *Tracking student progress*
  Gradebook programs and databases to update student profiles and maintain records.
- *Communicating*
  Telephone, voice mail, e-mail to contact parents, other teachers, or administrators to plan meetings, discuss student and administrative concerns.

Enhancing professional development

- *'Just-in-time" training and support*
  Satellite, video, cable, or computer access to new ideas, master teachers, and other experts for training and followup.
- *Formal courses and advanced degrees*
  Distance learning technologies for courses not available locally.
- *Informal educational opportunities*
  Online contact with teacher colleagues and other experts.

Preparing new teachers



- *Models of effective teaching*
  Video can take prospective teachers into classrooms to watch effective teachers in action.
- *Computer and video simulations and case studies*
  Give prospective teachers practice solving teaching challenges in a non-threatening environment.
- *Electronic networks*
  Minimize violation during field experiences, provide support and interaction with college faculty or mentors.

SOURCE: Office of Technology Assessment, 1995 ing.[10] Among the changes teachers reported were that they expected more of students, became more comfortable with students working independently, presented more complex material, tailored instruction more to individual needs, and spent less time lecturing and more time overseeing small groups or working one-on-one with students (see chapter 2, box 2-1). Some teachers suggest that using technology has meant they are transforming the educational process—their curriculum and classroom organization. These teachers report that, ultimately, they see a change in their roles as they become more like coaches, encouraging, guiding, and facilitating student learning, and students assume more initiative and responsibility for their own learning. While not all teachers want to make this transition from "sage on the stage to guide on the side," many find it exhilarating.

Assisting with Daily Tasks of Teaching

Teachers perform a wide variety of duties in addition to being instructional leaders, including preparing lesson plans and instructional materials, keeping and transmitting records of student progress, attending school meetings, meeting with parents, and staying abreast of the profession. Yet schools rarely consider the role of technology in assisting teachers with the many parts of the job that go on when the students are not present. And few schools have contemplated how teachers could use their time differently or how teaching personnel could be assigned more flexibly (e.g., teachers working with small groups of students for some parts of the day, large groups at other points) if teachers were freed from mundane tasks that technology could handle.[11]

Technology can assist teachers with daily activities in many ways:

- With electronic gradebook software, teachers can keep and more easily update running grading histories and profiles for every student and counsel them about problems as soon as they occur.
- Teachers can videotape student presentations to evaluate and maintain records of student performance as a part of assessment activities.
- By accessing an electronic database, a teacher can quickly locate a host of current materials relevant to next week's science lesson.
- A teacher can retrieve a voice mail message, at a convenient time, about a change in the time of a parent conference.
- Teachers can plan meetings with other teachers online and save time in coordinating multiple schedules.

OTA has observed that, as teachers develop expertise in these administrative applications, confidence grows, encouraging them to try additional applications to meet instructional and professional development goals.

Enhancing Professional Development for Today's Teachers

Teachers are learners too. They take courses, workshops, and other forms of training to fulfill recertification requirements, learn new instructional methods, or keep up with changes in their specialties. However, the current approach—typically a short inservice course on a specific topic in which a large group of teachers are gathered in one place for an "injection" of training—is limited and often disliked by teachers, administrators, and parents alike. For example, a school district may gather elementary school teachers from across the district to spend a morning learning about a new strategy for teaching reading. This "one-size-fits-all" model of training is rarely used in other pro-

[10] Karen Sheingold and Martha Hadley, *Accomplished Teachers: Integrating Computers into Classroom Practice* (New York, NY: Center for Technology in Education, Bank Street College of Education, September 1990).

[11] See, e.g., Margaret Riel, "The Future of Teaching," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, Jan. 12, 1994.

BOX 1-4: What Difference Does Educational Technology Make?

When a technology is introduced in education, many people want to compare its effectiveness with that of existing methods of instruction. In the 1960s and 1970s, a number of studies compared learning via radio and television with learning via classroom lectures or textbooks. More recently, many studies have been conducted comparing computer-assisted instruction with more traditional methods of instruction. These studies have consistently demonstrated that computer-assisted instruction technologies are either equivalent or superior to conventional instruction.[1] Meta-analyses, which examine the results of many studies and aggregate their combined effects, show effects that range from .26 to .66 standard deviations, which represent a sizable improvement on many achievement measures as well as positive attitudinal effects.[2] Small, but growing, numbers of studies have begun to examine effects of newer technologies such as videodisc or telecommunications networks.

Several factors belie simplistic approaches to the important but complex question of effectiveness. These issues include:

- *Conceptual* factors—are researchers, parents, teachers, and policymakers asking the right questions and interpreting available research correctly?
- *Methodological factors*— is the research designed well enough to answer questions of effectiveness? and
- *Timeliness factors*— with rapid advances in technology, including rapid obsolescence of yesterday's "new" technologies, do the research results tell interested parties what they need to know today to plan tomorrow's classroom uses of technologies?

Conceptual Issues. In general, many available studies of the effectiveness of educational technologies can be thought of as "horse race" studies because, when interpreted too simplistically, they are expected to provide evidence that one technology can "beat" another by showing that students "learn more" when it is used.[3] This approach can be misleading.[4] Whenever a new educational treatment is tried its effects are not just attributable to the technology (e.g., computer, video, books) but also to the particular content (e.g., subject matter, targeted skills) and pedagogical approach (e.g., software, teaching materials, teachers, and classroom environment). The type of learner (e.g., age, previous achievement, special needs) also influences the effects of these other variables on learning. In other words, it is not the effects of the technology by itself that are analyzed in these studies, but the aggregated effects of *how the technology is being used in the classroom context.* Available and future research should be interpreted with an eye to these factors, which can attenuate or enhance the effects of particular technologies.

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[1] See, e g., C. Kulik and J.A. Kulik, "Effectiveness of Computer-Based Instruction' An Updated Analysis, " *Computers in Human Behavior, vol.* 7, pp. 75-94; John Pisapia and Stephen M. Perlman, "Learning Technologies in the Classroom A Study of Results" (Richmond, VA: Metropolitan Educational Research Consortium, Dec. 1992); Alice Ryan, "Meta-analysis of Achievement Effects of Microcomputer Applications in Elementary Schools," *Educational Administration Quarterly,* vol. 27, No. 2, May 1991, pp. 161 -184; Interactive Educational Systems Design, Inc., *Report on the Effectiveness of Technology in Schools,* 1990-1994 (Washington, DC: Software Publishers Association, n.d.).

[2] Mark W. Lipsey and David B. Wilson, "The Efficacy of Psychological, Educational, and Behavioral Treatment. Confirmation from Meta-analysis,'' *American Psychologist,* December 1993; Effect size (ES) is a measure of the difference between a control group that did not use the technology and the treatment group that did. ES is expressed in standard deviation units. "An ES of 17 is quite small and unimportant, whereas an ES of 33 is modest but important To interpret the numbers more easily, they can be converted to percentiles. For example, an effect size of .33 means that the treatment group would be at the 63rd percentile compared with the control group at the 50th percentile." (J. Johnston, *Electronic Learning, 1987,* p 50)

[3] Barbara Means et al , *Using Technology to Support Education Reform* (Washington, DC: U.S. Government Printing Office, September 1993), p. 73.

[4] Means et al., op. cit., footnote 3, Ann D. Thompson, Michael R Simonson, and Constance P. Hargrave, *Educational Technology: A Review of the Research* (Washington, DC. Association for Educational Communications and Technology, 1992).

BOX 1-4 (cont'd.): What Difference Does Educational Technology Make?

Methodological Issues. It is important to note that there are several basic factors frustrating researchers, teachers, and policy makers looking for simple yes or no answers about technology's effectiveness. One is the overall context of real world educational research. As one researcher noted, "Schools are messy and noisy environments for research, far from the pristine, controlled setting available in the research laboratory, the model on which most quantitative evaluation studies are based. "[5] Comparable comparison groups are scarce; interventions with technology are usually a part of broader interventions that also influence outcomes; and different treatments for experimental and control groups run counter to a teacher's impulse to treat all students equitably.

A second major flaw in the existing research is the lack of good outcome measures for assessing the impact of technology-based innovations. Most of the research to date relies on existing measures of student achievement (e.g., standardized achievement tests). Although there are many promising efforts to broaden the kinds of indicators that can be used to assess student achievement, these are not yet in widespread use.[6] New achievement measures would assess areas that many believe can be particularly affected by using new technologies (e.g., higher-order thinking). Also key, however, is the need to include outcomes that go beyond student achievement, because student achievement may be affected by students' attitudes about themselves, school, and learning, and by the types of interactions that go on in schools. For example, some research has documented the positive effects of computer-assisted instruction on students attitudes about school and learning.[7] Also promising is recent research that suggests that technology-based innovations can affect student self-concept as well as interactions between students and teachers in the classroom environment.[8] Technological changes are likely to be nonlinear, and technological changes may show their impacts not only on student learning, but also on the curricula, the nature of instruction,[9] the culture of schools, and the fundamental ways teachers do their jobs.

Timeliness. The rapid pace and the potentially high cost of some technological changes[10] create a dilemma for the typically slower pace of careful research. Policymakers—and taxpayers-faced with deciding whether to invest millions of dollars in an information infrastructure typically want to know whether their investment will be worth the increased financial burden (assuming technology does not replace existing methods). For example, they will want to know whether what is on the '(information superhighway" will really help their children achieve, whether putting a telephone on every teacher's desk will really improve parent-teacher communication, or whether investing in new personnel to provide "just-in-time" support for technology-using teachers will enhance the instructional capabilities of existing technology investments. Equally reasonable seem the frustrations of those who have experienced the promise of particular educational technologies in small experimental programs (e.g., downloading real-time information on weather data from satellites for science lessons). By the time the external evidence has been compiled, "proving" that technology integration works and districts are ready to commit to purchases of the appropriate hardware and software, the technology that has been researched may be obsolete and a golden opportunity to use it for current students will have been lost.

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[5] Joan O. Herman, "Evaluating the Effects of Technology In School Reform, " *Technology and Education Reform The Reality Behind the Promise,* Barbara Means (cd.) (San Francisco, CA. Jossey-Bass Publishers, 1994), p. 145

[6] See *Testing in American Schools: Asking the Right Questions,* OTA-SET-51 9 (Washington DC: U.S. Government Printing Off Ice, February 1992),

[7] Thompson et al., op. cit., footnote 4.

[8] J. Sivin-Kachala and Ellen R. Bialo, *Report on the Effectiveness of Technology in Schools:1990-1994* (Washington, DC, Software Publishers Association, n.d.).

[9] Jerome Johnston, *Electronic Learning: From Audiotape to Videodisc* (Hillsdale, NJ: Lawrence Erlbaum, 1987).

[10] The costs of educational technologies are not known with certainty. What is known is that they will vary considerably depending on an array of factors. See section on "Costs" later in this chapter

(continued)

BOX 1-4 (cont'd.): What Difference Does Educational Technology Make?

Directions for the Future. Although there are some promising studies, more research on the broad variety of educational effects of technology is needed. A more fruitful research approach than merely asking whether a particular technology works is to ask about the "value added" to instruction when technology is present in schools; in other words, when, why, and how do technologies improve teaching, professional development, and, ultimately, learning for children? Increasingly, researchers are concentrating their efforts on this type of more contextualized research—studying how complex-technology-based innovations "work" in real classroom settings over time. Such research can help to determine how technology environments can best be designed to support student learning and what approaches to instruction work best in conjunction with various types of technologies for what kinds of subject matter. The role of the teacher in implementing and facilitating student learning in such environments is an important focus of such studies. '[11] Additional research models are needed to deepen understanding about which instructional uses of technology are most effective and under what circumstances, and how teacher interactions with technology play into this effectiveness. By taking a more contextualized approach, research can help schools, parents, teachers, and policymakers understand the necessary steps to diffusing and continuously refining educational technologies in the schools.

[11] For examples of this kind of research see A.L. Brown, "Design Experiments Theoretical and Methodological Challenges in Creating Complex Interventions m Classroom Settings, " *Journal of the Learning Sciences,* vol. 2, No. 2, pp. 141-178, Cognition and Technology Group at Vanderbilt, "The Jasper Experiment An Exploration of Issues in Learning and Instructional Design, "Educational *Technology Research and Development, Vol.* 40, pp. 65-80, 1992.

SOURCE: Office of Technology Assessment, 1995.

fessions, and, although it may be efficient for school districts, many suggest it is not the most effective way to encourage teachers to learn new skills or teaching approaches. It appears to be a particularly ill-chosen method for encouraging teachers to use technology, where hands-on training with the hardware and software, curriculum-specific applications, and followup support are all necessary.

OTA has found examples of how technology can provide teachers with "just-in-time training and support" when and where they need assistance in many curricular areas. It can transcend the walls of isolation that separate teachers and extend formal and informal learning opportunities. The following are some examples:

- Without leaving their school buildings, teachers from across the 90 school districts in sprawling Los Angeles County can participate in a satellite staff development course on topics such as how to apply the California history and social science framework in lessons in their classrooms.
- School counselors from across Wyoming meet regularly over a compressed video network to discuss student truancy and behavior problems.
- A special education professor at the University of Northern Iowa offers courses to teachers throughout the state over the Iowa Communication Network. With this fiberoptic network, teachers at each site can see and hear each other as they develop skills for adding the certification credits that will enable them to teach students with moderate, severe, and profound mental disabilities.
- Mathematics teachers use a computer network to discuss the mathematics teaching techniques they have observed through video presentations in the Mathline project sponsored by the Public Broadcasting System.

- Using cable television, teachers from remote locations around the country can take courses leading to a masters in educational technology degree from George Washington University in Washington, DC.

In examples like these, technology can be the vehicle for providing teachers access to new ideas, master teachers and other professionals beyond their school setting, in both formal and informal courses and enrichment activities. It can also provide the support teachers need after a course ends, as they apply and refine in the classroom the lessons and techniques they have learned.

■ Preparing New Teachers with Technology

In colleges of education where technology is an integral part of the teacher education preservice program, technology has been used not just to train prospective teachers about technology, but also as a resource to enhance the overall teacher preparation experience. For example, live broadcasts, tapes, video networks, CD-ROMs or videodiscs can provide teacher education students with case studies or models of effective teaching. Furthermore, technology-whether computer or video networks-can create closer connections among student teachers, college of education faculty, and mentor teachers in K-12 classrooms, whether in lab schools or professional development schools closely allied with colleges of education, or in more traditional student placement activities. Electronic networks can provide a safety net for communication, sharing knowledge, and experience for student teachers in the field, as well as for new teachers launching their careers. The loneliness and anxiety common to teachers' first teaching experiences can be mitigated through contact with professors and peers via electronic networks. The following are examples of ways technologies have enriched preservice teacher education:

The use of technology in teacher preparation programs is limited, but it can enhance the overall preservice experience.

- Teacher education students at the University of South Carolina appreciate what students with language learning disabilities might experience when dealing with text by working with a software simulation called "The Language Mangler." Another simulation serves as a surrogate field observation, enabling prospective teachers to observe, critique, and discuss ways teachers handle students with special needs in a variety of settings.
- At the Peabody College of Education at Vanderbilt University, teacher education students review CD-ROM discs that contain video cases of mathematics teachers working with students. Teacher education students can each have copies of the inexpensive CD-ROM discs, play them on computers supplied with CD-ROM drives in dorms and on campus, and review teaching techniques individually or in a group. They add notes and observations on accompanying software that serves as an electronic notebook, which instructors then collect electronically for grading and return.
- All the schools in which the University of Virginia's Curry School of Education preservice students spend their internships are linked to Virginia's Public Education Network, permitting the teaching intern, the supervising teach-

er, and the faculty at the Curry School to confer via the electronic network throughout the teaching internship.

- At the Price Lab School at the University of Northern Iowa, a fiberoptic network linking the college and the lab school enables teachers in any of the 48 classrooms at the lab school to ship video to teaching methods classes. Teacher education students see lessons related to topics they are discussing in their courses and, with two-way video and audio, talk to the teacher after they see the lesson and hear the teacher's on-the-spot analysis of what worked and what was problematic in that lesson. Since most lab school faculty use technology in their classes, the teacher education students can see effective modeling of technology use via technology.
- University of Wyoming students conducting student teaching meet via a compressed video system with their supervising faculty member, collaborating teacher, and clinical supervisor as often as necessary to discuss problems and questions arising out of student teaching experiences.

TEACHERS AND TECHNOLOGY: THE BARRIERS

While promising, the above examples of what technology can do are far from the reality in many schools, in colleges of education, or in the daily teaching experience or professional development of the typical teacher. There are a number of common barriers to more widespread use of technology by teachers (see table 1-2):

- First, there is the question of access to appropriate technologies. The question of access is also tied to problems of costs.
- Although most teachers see the value of students learning about computers and other technologies, many teachers lack a clear understanding about what resources technology can offer *them* as they try to meet their instructional goals.
- As do most users of emerging technologies, many teachers encounter technical and logistical problems they cannot solve themselves and often lack the training and support necessary to resolve the problems.
- Many feel the need for more knowledge—not just about how to run the machines—but about what software to use, how to integrate it into the curriculum, and how to organize classroom activities using technology.
- The current assessment system, if it relies heavily on standardized achievement tests, can also be a barrier to experimentation with new technologies because teachers are not sure whether the results they are seeking will be reflected in improved student test scores.
- In addition, issues created by technology itself are also factors to be dealt with, including those related to copyright and intellectual property rights, privacy of student records, and control of student access to objectionable materials.

Access Issues

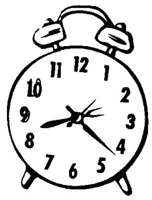
Equipment

One basic prerequisite for effective teacher use of technology is access. Schools have made substantial investments in hardware and software over the past several years, increasing their technology inventories (see box 1-3). OTA finds that, despite past investments in technology, many schools still lack the basic technology infrastructure to support the most promising applications of educational technology. About half the computers in U.S. schools are older, 8-bit machines that cannot support CD-ROM-sized databases or network integrated systems or run complex software. This aging inventory limits the ability of many teachers to use some of the most exciting applications of computers—information gathering from networked databases or CD-ROM encyclopedias, desktop publishing, mathematics instruction using analytic graphing and calculating software, and collaborating in joint projects over networks.

Some schools do not always make the most of the equipment they already have, and some do not

TABLE 1-2: Teaching and Technology: Current Barriers

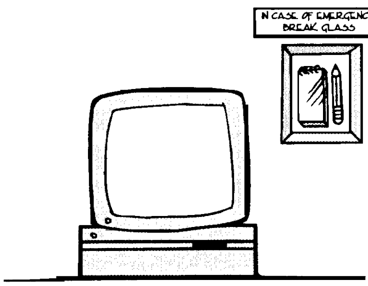
Teacher time



Teachers need time to:

- Experiment with new technologies.
- Share experiences with other teachers.
- Plan and debug lessons using new methods that incorporate technologies.
- Attend workshops or training sessions.

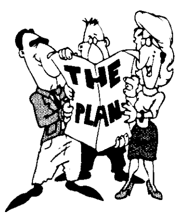
Access and costs



In addition to limited hardware and software, other factors affect access:

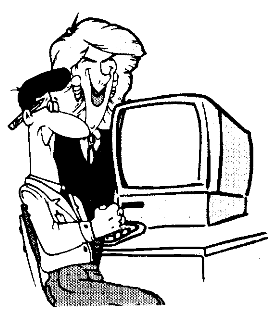
- Costs are high for purchasing, connecting, and training to use technologies.
- Technologies may not be located in or near the classroom.
- Hardware in schools today is old (50 percent of computers in schools are 8-bit machines) and cannot handle many newer applications.
- New or additional wiring or phone lines are necessary for telecommunications networks.

Vision or rationale for technology use



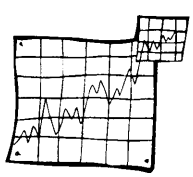
- Schools must have plans, and teachers a clear understanding of curricular uses of technology.
- It is difficult to keep up with the rapid rate of technology development and changing messages of best use.
- Teachers lack models showing the value of technology for their own professional use.

Training and support



- Overall, districts spend less than 15 percent of their technology budgets on training, but they spend 55 percent of the budget on hardware and 30 percent on software.
- Technology training today focuses primarily on the mechanics of operating equipment, not on integrating technology into the curriculum or selecting appropriate software.
- Only 6 percent of elementary and 3 percent of secondary schools have a full-time, school-level computer coordinator for technical support.

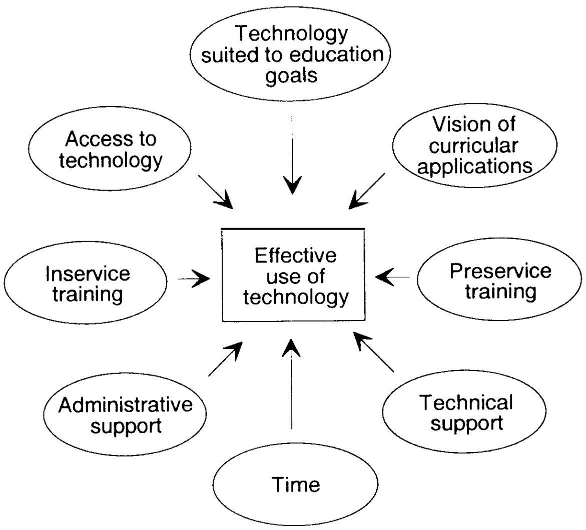
Current assessment practices



- Existing standardized measurements of student achievement may not reflect what has been learned with technology.
- Teachers are held immediately accountable for changes that take time to show results.

SOURCE: Office of Technology Assessment, 1995.

FIGURE 1-1: Requirements for Effective Use of Technology



SOURCE. Office of Technology Assessment, adapted from Jane L. David, "Realizing the Promise of Technology Policy Perspective" in Barbara Means (ed), *Technology and Education Reform* (San Francisco. Jossey-Bass Publishers, Inc., 1994), pp. 169-189

always locate technology in the most accessible places. Most computers are still in labs rather than in classrooms, and modems may be located on a central computer in the principal's office, making it hard for teachers to use them during the course of a day. Thus, it is not surprising that computers are not used very often (about two hours per student per week, according to coordinators; less, according to the students). They are not used regularly in the teaching of academic subjects—only 9 percent of secondary school students reported using computers for English class, 6 to 7 percent for a math class, and 3 percent for a social studies class. The most common uses of computers are for basic skill practice at the elementary level and word processing and other computer-specific skills in middle and high schools. Other uses, such as desktop publishing, developing math or science reasoning with computer simulations, gathering information from databases, or communicating by electronic mail (e-mail) are much rarer. And, despite the growing interest in connecting schools with information resources like the Internet, most school districts with local area networks do not always configure them or use them for the most up-to-date applications.

Furthermore, a majority of schools are ill--equipped to take advantage of the potential presented by telecommunications networks. Fewer than one teacher in eight has a telephone in the classroom that can be used for outside calls. Moreover, most schools lack the connectivity, administrative and organizational support, and technical expertise needed to integrate networks into teaching and learning.

OTA finds that it is necessary to consider a new definition of what constitutes "access" to technology by teachers and students. Counts of equipment, student-computer ratios, dollars spent and requirements, while important, alone are not sufficient to define meaningful access to technologies. It is appropriate rather to consider infrastructure in a broader sense: type of technology (including older but overlooked resources such as the telephone), age, capacity, connectivity, software, and services. Organizational arrangements—the placement and flexibility of technology—also affect the ease of use by teachers and students. For example, a cart of laptop computers that can be moved anywhere in a school may be used much more often than a computer lab far from the classroom. An additional component of a new definition of access includes the kinds of support teachers need to use the infrastructure effectively: exposure to innovative uses, flexible "just-in-time" training, and ongoing technical support and expert advice.

If access to technology is an equity concern, then the definition should be expanded to encompass access to necessary information. Telecommunications and networking technologies, in particular, may create incomparable opportunities for teachers and students to gain immediate access to information. Combined with hardware like CD-ROM players, the excitement and power of video can be combined with the information transmission power of the computer and communication capabilities of high speed networks. Connectivity is likely to become the major technology issue of the next several years. Major investments of time and other resources will be required to prepare ‘schools to effectively access the information and electronic communities telecommunications can provide.

costs

As new technologies, new opportunities for increased levels of connectivity, and educational applications emerge, those concerned with expanding the use of technology in schools and by teachers have turned their attention to the issue of cost.[12] The cost of any new initiative is always an issue for elementary and secondary education, which is funded almost exclusively by a combination of state and local taxpayers. Some have suggested, however, that there be greater roles for the federal government, private businesses, or some combination to ensure that schools obtain new technologies. These suggestions have stimulated the Congress to direct the U.S. Department of Education (ED) to estimate costs on a national basis.[13] The ED estimate, to be developed by the Rand Corporation under contract to ED, was not available at the time this report was prepared. Previous attempts at rough estimates, at the state and national levels, can be informative in illustrating the range of costs-and the range of uncertainty—involved.

States vary greatly in their installed base of technology, their technology plans and goals, and the numbers of students served (see chapter 3, figure 3-5). Consequently, states will require varying levels of funding to meet these goals. For all states, however, substantial commitments will be required.

The costs of technology are a major hurdle for many schools.

Table 1-3 estimates installation and operating costs of selected telecommunications technologies. The table is based on rough estimates by OTA of the costs of installing telephone lines in all U.S. classrooms, and by projections made by two economists[14] based on various configurations for connecting schools, school districts, and/or classrooms. Analysis of the estimates suggests that at ***the national level*** and ***depending on a variety of factors:***

- estimated one-time installation costs (including training) ***may range*** from $0.08 billion (for one personal computer plus modem per school, connected to the Internet through a school-district-based file server) to $145 billion (to have one personal computer per student desktop, with full, ubiquitous connection to the Internet for a complete suite of text, audio, graphical and video applications); plus
- estimated annual operating costs for the configurations described above (including annual

[12] See, e.g., Russell I. Rothstein, "Connecting K-12 Schools to the NII: A Preliminary Assessment of Technology Models and Their Associated Costs," a working paper (Washington, DC: U.S. Department of Education, Aug. 4, 1994); Robert Cohen, "The Cost of NII Access to K-12 Schools: preliminary Assessments," paper provided by Robert Blau, director, Policy Analysis, Bell South, Washington, DC, 1994.

[13] See, **e.g., Public** Law 103-382, Title III.

[14] Rothstein and Cohen, op. cit., footnote 12.

TABLE 1-3: Estimated Installation and Operating Costs of Selected Telecommunications Technologies

Examples of technology, training, support, and infrastructure configurations	Source of estimate	Range of estimated one-time installation and training costs	Range of estimated annual operating costs	Limits on capability
Telephone in each public school classroom.	OTA[a]	$123.00 mil.[b] (low) - $220.00 roil. (high)[c]	$310.00 mil. (low)[d] - $333.00 mil. (high)[e]	Phone line could be used to connect to modem.
One personal computer (PC) plus modem per school, connected to a school-district-based file server, connected to the Internet, with minimal initial teacher training, and $2-$10K per year for teacher support and $1-$5K per year for teacher training.	Rothstein, 1994	$80.00 roil. (low) - $390.00 roil. (high)	$160.00 mil. (low) - $560.00 mil. (high)	Limited access by teachers and students; allows text-based applications only (e.g., e-mail, telnet, gopher).
An average of 60-100 PCs, modems, and a local area network (LAN) using copper wire per school; district-based file server to remote locations, IAN, router to the Internet; initial teacher training of 5 to 20 staff per school, and annual teacher support and training.	Rothstein, 1994	$2.59 bil. (low)- $7.75 bil. (high)	$1.37 bil. (low)- $3.38 bil. (high)	Supports only a few users at a time because it is limited by the number of phone lines going out of the school.
One PC per classroom with additional dialup lines. Districts support file server to remote locations, LAN, and router to the Internet; with initial teacher training of 10-20 staff per school and annual teacher support and training of 1-2 support staff per district, and $10-20K for training. Includes major retrofitting costs.	Rothstein, 1994; Cohen, 1994	$5.38 bil. (low)- $13.26 bil. (high)	$1.30 bil. (low)- $3.84 bil. (high)	No real-time access to video or graphics.

60 PCs per school plus LAN, file server with high-speed links, and router. District offices have IAN, file server to remote locations, and router; with initial teacher training for 40-50 staff per school and annual teacher support and training of 3 support staff per district, plus annual training costs of $15-$35K.	Rothstein, 1994	$11.75 bil. (low) - $27.53 bil. (high)	$1.85 bil. (low) - $4.94 bil. (high)	Base needed for connecting each public school to the Internet, allowing use of "limited" video, graphical and text-based network applications.
1 PC per desktop, plus school-based IAN, a larger file-server, and router to district office; each district has a file server to remote locations, LAN, a high-speed line to school; and a larger dialup system than in previous model; with initial teacher training for all teachers in all schools, and annual teacher support and training consisting of 4-5 support staff per district; plus annual training costs of $16.5-$38.5K. Includes significant retrofitting costs.	Rothstein, 1994	$65.80 bil. (low) - $145.62 bil. (high)	$4.46 bil. - $11.28 bil.	Full connection to the Internet, supports full suite of text, audio, graphic and video applications. Would not support full-motion video.
4 schools per district have PCs, LAN, file server/router; each district has a file server LAN, a data line to wide area networks, and dialup lines; assumes initial training costs of $100K and annual support and training costs of$133K total. Includes costs of retrofitting school buildings.	Cohen, 1994	$35.76 bil.	$5,49 bil.	None: individual schools linked directly to a national information infrastructure; circuit can accommodate very wide array of services including full motion video.

[a] Figures do not reflect the fact that one-eighth of classrooms now have phones; thus, these estimates may be too high

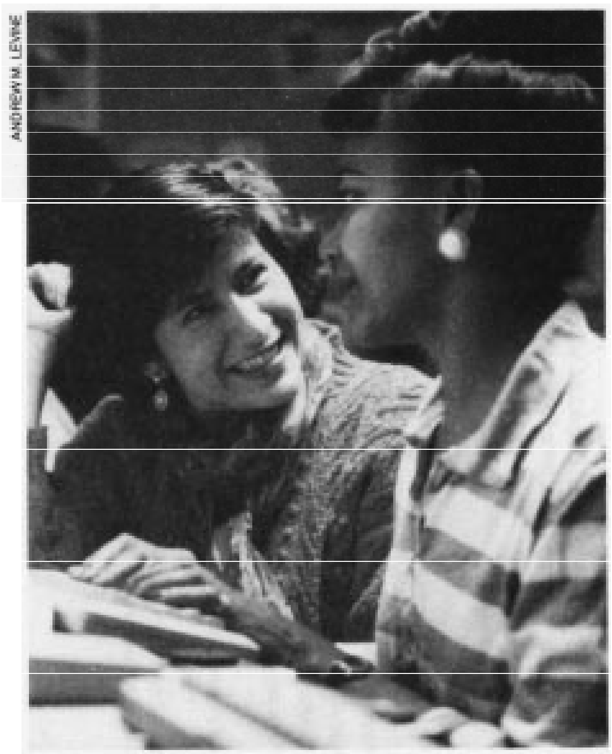
[b] Based on an estimate of 83,389 public schools (Software Publishers Association, 1994), with an average of *20* classrooms per school (Rothstein, 1994).

[c] Includes additional charges for labor and installation (optional) of $42 upfront charge, plus $16 for 15 minutes (per classroom), for an additional cost of $96,731,240,

[d] Calculated for regular (non-centrex) service as follows: $16.77 per line monthly charge + $1.45 per month message unit charge [@20 message units per month] = $18.22 X 10 months in school year X 1,668,000 classrooms = $303,909,600 Figures may not total exactly due to rounding.

[e] Calculated for centrex service as follows: $18.22 per line monthly charge + $1.45 per month message unit charge [@ 20 message units per month] = $1995 X 10 months in school year X 1,668,000 classrooms = $332,766,000= $291,170,250 Figures may not total due to rounding

SOURCE" Off Ice of Technology Assessment, 1995, based on Russell I. Rothstein, "Connecting K-12 Schools to the NII: A Preliminary Assessment of Technology Models and Their Associated Costs, " a working paper (Washington, DC U S Department of Education, Aug. 4, 1994); Robert Cohen, "The Cost of NII Access to K-12 Schools" Preliminary Assessments, " paper provided by Robert Blau, director, Policy Analysis, Bell South, Washington, DC, 1994



Teachers working together can create a shared vision for technology use.

training and support for teachers) may *range* from \$0.16 billion to \$11.28 billion.

The range in the estimates in table 1-3 is striking, and the estimates could easily be far from the mark. Furthermore, these estimates have not considered costs of using additional technological configurations that offer potential, such as cellular telephones and wireless modems.[15]

Key factors that appear to account for current differences in available estimates include:

- the configuration of technologies envisioned for the estimate (from a simple telephone line, to technologies that are on the cutting edge);
- the number of desktops, classrooms, school buildings, and school districts that are assumed to obtain access to the system'
- the amount of retrofitting required of school buildings (e.g., to install new wiring for telephone and cable lines or to provide additional electrical power, to deal with asbestos during required construction); and
- the amount of support and training required for the human resources-the teachers-to make best use of the new technologies.

Clearly, different assumptions about these factors-and development of new, perhaps less expensive, technologies in the future-could greatly affect cost projections. In addition, at the local level, prices for individual technologies may vary considerably, meaning that any one school, school district, or state could experience a considerably different level of costs than any other.[16]

■ A Vision of Goals and Rationale for Technology Use

There is also a gap between having technology and using it effectively. As described above, equipment is often placed in locations where it is inconvenient for regular classroom use. Furthermore, schools and teacher share received conflicting advice over the years about the best ways to use their technology. As the technology has evolved, so has the prevailing wisdom on how teachers should use technologies in schools-from teaching programming, to encouraging individualized drill and practice, to building computer literacy, to participating in electronic communities. Conventional thinking also has shifted about how to organize technology resources, from self-contained labs, to one computer per classroom for teacher demonstrations or single student tutorials, to a few computers per classroom on which stu-

15 See U.S. Congress, Office of Technology Assessment study on wireless telecommunications, forthcoming.

16The policy issues and options section of this chapter provides examples of different state policies (e.g., with respect to group puchasing, with respect to subsidies for telecommunications charges) can affect the costs actually incurred at the local level.

dents can work in small groups, to one computer per student and on the teacher's desktop. It is small wonder that teachers have become confused, and administrators frustrated, with many educators unclear where they should be headed in directing technology use.

Support and Training

Other barriers in many schools hamper more effective use of technology by teachers. These include lack of time, inconvenient scheduling, attitudinal barriers, and barriers of school organization, curriculum, testing, and other policies.

In general, teachers have little in the way of technology support or training available at their schools, although many teachers seek training on their own. Currently schools spend much more on hardware (55 percent) and software (30 percent) than they do on training (15 percent). Less than half of American schools report that an introductory computer course is available for teachers through the district or a local college.

Furthermore, the kind of training, not just availability, is important. Much of today's educational technology training tends to focus on the mechanics of operating new machinery, with little about integrating technology into specific subjects, how to choose software, and how to organize classes, e.g., to use four computer workstations or a single computer with a modem.

Regular, onsite support for technology use is an even more daunting problem. Only 6 percent of elementary and 3 percent of secondary schools have full-time school-level computer coordinators; in nearly three-fifths of schools, no one had any portion of their workweek officially allocated to coordinating computer activities. Even in schools where someone is designated to spend at least half of his or her time as computer coordinator, very little of this time goes directly to training or helping teachers use computers.

Probably the greatest barrier to technology use, however, is simply lack of teacher time—time to attend training or workshops, to experiment with machines and explore software, to talk to others teachers about what works and what doesn't, and to plan lessons using new materials or methods. The diverse jobs teachers are asked to do and roles they are asked to play also affect their ability to take on another challenge. Teachers are given very little compensated staff development time and there are multiple competing demands for this time. Unless there are significant changes to the rhythm of the school day or changed incentives for giving teachers more time to learn and experiment with new technologies, this barrier to technology use will remain immense.

Other Emerging Issues

As the possibilities for widespread information networks—and their use by schools, teachers, and students—emerge, other issues are coming to light that may affect the ability of teachers to use technologies for administrative, instructional, and professional development purposes. These issues include copyright and intellectual property issues, privacy of student records, and censorship of objectionable materials versus protecting students' access to potentially valuable information.

Copyright and Intellectual Property Issues

Currently, one of the most widespread and promising uses of telecommunications technology by teachers is the retrieval of information from remote sources, including networked information, collections of books, journals, music, images, databases, software, and multimedia works—so-called digital libraries.[17] As students and teachers develop multimedia materials or projects, share them with colleagues, and store them in portfolios for student and teacher evaluation, use of copyrighted works in the classroom could grow dra-

[17] Margaret Honey and Andrés Henriquéz, *Telecommunication and K-12 Educators: Findings from a National Survey* (New York, NY: Center for Technology in Education, Bank Street College of Education, 1993).

matically. Some examples of student use of such materials might include:[18]

- creating a Quicktime clip from a segment of a videodisc of a popular movie,
- digitizing a video clip from a "60 Minutes" segment,
- scanning a copyrighted photograph to use in a Hyperstudio program,
- using music from a compact disc for background, and
- scanning a copyrighted picture of "Goofy" to use in a project.

Teachers' use of new media and curriculum development activities using copyright materials might include such activities as:

- keeping student developed multimedia projects using materials cited above as examples to show others,
- showing multimedia projects at professional conferences,
- sharing multimedia projects over the school district's cable channel,
- using an object from a copyrighted authoring program in another courseware authoring program for teaching purposes, and
- sharing projects on a listserv on the Internet.

These applications all raise issues related to fair use of copyright material and copyright protection.

The nature of digital works also changes how people read or use the works,[19] which presents new challenges to educators for the proper use of intellectual property. In earlier work,[20] OTA has found that the application of intellectual property law to protect works maintained in digital libraries continues to be uncertain; concepts such as "fair use" are not clearly defined as they apply to these works, and the means to monitor compliance with copyright law and to distribute royalties are not yet resolved. Resolution of these issues will provide teachers with clearer guidance for using digital information; meanwhile, school systems must struggle to remain in compliance with the existing law.

Privacy of Student Records

Use of computers by teachers may raise new issues of privacy for teachers and their students. One area of particular concern is computerization of student records. Increasingly, educators and policymakers will use data gathered and maintained in computers to monitor progress toward educational achievement standards, determine how well curricular content areas are covered, track performance of all students, and analyze information about special groups, such as disadvantaged and language-minority children.[21] In some states, lawsuits have challenged the right of state educational agencies to create computerized records by

[18] Rosemary Taub, College of Education, Kansas State University, personal communication, August 1994.

[19] Digital information differs from information maintained in more traditional forms (e.g., analog) in several ways: 1) digital works are easily copied, with no loss of quality; 2) they can be transmitted easily to other users or be accessed by multiple users; 3) they can be manipulated and modified easily and changed beyond recognition; 4) they render text, video, and music to an essentially equivalent series of bits and store them in the same medium; 5) they are inaccessible to the user without hardware and software tools for retrieval, decoding, and navigation; and 6) with appropriate software, they create opportunities to experience works in new ways, for example, interactive media.

[20] U.S. Congress, Office of Technology Assessment, *Finding A Balance: Computer Software, Intellectual Property, and the Challenge of Technological Change,* OTA-TCT-527 (Washington, DC: U.S. Government Printing Office, May 1992).

[21] National Education Longitudinal Study of 1988, Student Questionnaire, prepared for the U.S. Department of Education, National Center for Education Statistics.

collecting individually identifiable data. Typically the legality of such data collections is upheld, but not always.[22]

The Family Education Rights and Privacy Act of 1974 (FERPA), commonly called the "Buckley Amendment" after former New York Senator James Buckley, was enacted in part to safeguard parents' rights and to correct some improprieties in the collection and maintenance of public records. The legislation establishes the right of parents to inspect school records, limits access to school records (including test scores) to those who have legitimate educational needs for the information, and requires written parental consent for the release of identifiable data.

The growing use of computers to collect and store potentially sensitive information also requires heightened awareness from computer users about their responsibility to respect confidentiality when accessing data. It is already evident to users of electronic information technologies that functions such as e-mail make the anonymity and ease of manipulating data within electronic communities far more likely.

Censorship and Protecting Student Access to Information

A particularly challenging issue for K-12 education is finding the appropriate balance between encouraging students' rights of access to information and protecting students from objectionable materials and potentially harmful contacts over wide area networks. Bringing the world into the classroom is a laudable concept, but it can also have a downside. Educators and parents are concerned that children will be able to gain access to pornographic, dangerous, salacious, or otherwise undesirable material over networks, material that might never be allowed in textbooks, school libraries, or at home. The same information superhighway that makes it possible for students to talk to the Archbishop of Canterbury or the state governor online could also link them to criminals, pedophiles, or psychopaths.[23] As one news article recently noted:

> The cyberspace battles may prove especially contentious, because the Internet contains a great many works not found on the shelves of most schools. "The School Stopper's Textbook," for instance, tells how to short-circuit electrical wiring, set off explosives in school plumbing and "break into your school at night and burn it down." . . .Schools can keep a pornographic book off the library shelf by not buying it, but they can't keep it from entering the building through cyberspace.[24]

Some educators fear that, without proper safeguards, concerns like this could block the educational potential of telecommunications in schools. Schools are also worried about the potential for litigation, since some states prohibit "exposing minors to dangerous material or information."[25] Some schools have addressed this issue by educating teachers about the potential "risks" on the Internet; others have developed network use policies that students and parents must sign. For example, a school district in Colorado sends home a notice warning parents that potentially "defamatory, inaccurate, abusive, obscene, profane, sexually oriented, threatening, racially offensive, or illegal material" exists online. [26]

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[22] Aaron M. Pallas, "Statewide Student Record Systems: Current Status and Future Trends," National Education Goals Panel, Mar. 26, 1992. Some teachers have also voiced concern that states will use the data for accountability purposes that teachers believe are inappropriate, thereby jeopardizing local autonomy. While most states do not use their statewide student record systems for accountability purposes, local districts and state education departments may disagree about the propriety of these purposes.

[23] Paul Evan Peters, "In Your Face in Cyberspace," *Educom Review*, September/October 1994, pp. 70-73.

[24] Stephen Bates, "The Next Front in the Book Wars," *The New York Times*, Educational Life Section, Nov. 6, 1994, p. 22.

[25] Ibid.

[26] Ibid.

Other schools have given accounts and passwords to teachers only, not allowing students access to telecommunications. However, many educators consider this educationally shortsighted, especially since the possibilities of exploration and freedom of inquiry are what many find so promising about the Internet.[27] Increasingly, schools have put some of the responsibility on the students, setting up rules for permissible "surfing" (browsing through discussion groups or information sources) and taking away student passwords or accounts if they engage in "hacking" (destroying files or other materials on a computer system) or "flaming" (using abusive or offensive language on e-mail). Still others seek technological solutions that block access to certain areas of the Internet: development is underway on "reverse firewalls" that keep users from going beyond prescribed areas on the Internet. Until such prototypes are in place, schools and teachers face a substantial challenge.

PROMISING APPROACHES TO TECHNOLOGY IMPLEMENTATION

> The challenge of integrating technology into schools and classrooms is much more human than it is technological. What's more, it is not fundamentally about helping people to operate machines. Rather, it is about helping people, primarily teachers, integrate these technologies into their teaching as tools of a profession that is being redefined through the . . . . process.[28]

Some schools and colleges of education are developing approaches to technology implementation from which others can benefit. The approaches differ, depending upon the existing resources (human and technological) at a site, the visions the sites have developed for how technologies are to be used and what problems they can address, and the leadership and support marshaled to meet those goals. These approaches include the following:

- developing technology-rich classrooms, schools, or districts, in which local expertise in various applications of technology can be developed and shared;
- training master teachers, who then serve as resources for their colleagues;
- providing expert resource people from other staff, such as librarians, computer coordinators, or volunteers from business, parent, and student groups;
- giving every teacher a computer, training, and time to develop personal confidence and expertise;
- training administrators so they can serve as technology supporters and guide efforts within their schools or jurisdiction; and
- establishing teacher or technology resource centers, ideally with ease of teacher access through online services.

Most schools combine several of these approaches, and there is no clear evidence that any one model is more successful than others. OTA found a number of promising practices, including the following examples:

- At Webster Elementary School in St. Augustine, Florida, all staff received broad training in technology use, but those interested were given more time, more training, and the opportunity to attend conferences. They became the "local experts" that other teachers could draw on for assistance or advice.
- To ease the burden of setting up alternative arrangements for substitutes, the Monterey California Model Technology Schools developed the concept of "SuperSubs," in which teachers on early retirement, armed with technology lessons and resources, substitute

[27] "Lifelong Learning and the NII," unpublished proceedings, Westfields Conference Center, Chantilly, VA., Nov. 18-20, 1994.

[28] Barbara Means et al., *Using Technology to Support Education Reform*, OR-93-3231 (Washington, DC: U.S. Department of Education, Office of Research, September 1993), pp. 83-84.

for other teachers who are then free to observe still other teachers' technology lessons and approaches.

- In Indiana, four schools were given grants allowing every teacher to receive a computer and printer for use at home or in school, to improve their personal productivity and, ultimately, instructional efforts. Training, involvement of support staff and administrators as well as teachers, and broad public commitment helped to meet the goals of the program.
- In the Apple Classroom of Tomorrow Teacher Development Center Project, principals are encouraged to attend training with teacher teams and commit to providing extra time and resource for teachers to work together, reflect on what they are learning and doing, and assist their colleagues in technology activities.
- Texas supports 20 regional education service centers, with extra funding to support technology initiatives, including such areas as technology preview centers, training first-year teachers and preservice teachers in technology use, and training personnel on the use of TENET, the statewide computer network for teachers, with connections to the Internet.

These examples suggest a number of important lessons for implementation (see box 1-5).

CURRENT FEDERAL SUPPORT FOR TEACHER TRAINING AND TECHNOLOGY

As in the past (see box 1-6), multiple categorical programs for different needs and niches continue to comprise the world of federal teacher training programs.[29] Of the 58 programs OTA has identified that support preparation of teachers to use educational technology of some sort, most are small (under $10 million). **What is striking about most of these programs is the optional nature of support for technology-related training.** Not one program is devoted exclusively to **technology-related** teacher training, although federal agencies sometimes choose, in the case of discretionary grant programs, to make technology-related teacher training an absolute priority for one funding cycle.[30] The programs that provide the most consistent funding for technology-related professional development usually combine technology with science and mathematics training or include technology-related activities for both teachers and students, as in the Star Schools program.

In myriad programs, it is up to state, local, or university grantees to decide whether technology-related training is provided at all and in what form. This is the case with large formula grant programs, such as the Title I Chapter 1 (usually referred to as) program for disadvantaged children and the Vocational Education Basic Grant program, as well as smaller demonstration programs, such as the National Science Foundation (NSF) Teacher Enhancement program. Even programs with a primary focus on teacher development seldom mandate or recommend that grantees consider technology as either a topic for training or a mode for delivery. And with few exceptions, the federal government does not collect data from grantees in the format or detail necessary to discern which projects are actually providing technology-related teacher development, or how much they are spending for it, or what the impact has been.

FEDERAL POLICY ISSUES AND OPTIONS

The appropriate federal role in education has always been debated. The extent to which there should be a federal role in assisting teachers to make the connection with technology is and will continue to be part of this debate.

There seems to be little question of whether technologies should be used in the nation's schools for purposes of instruction, administra-

[29] The General Accounting Office counted 86 programs supported by the federal government in support of teacher training of all kinds. "Multiple Teacher Training Programs" (Washington, DC: U.S. General Accounting Office, February 1995).

[30] An *absolute priority* means that only projects that address the priority will be funded in a given year. Priorities change from year to year.

BOX 1-5: Some Lessons About Technology Implementation

A number of schools, districts, and states have made the adoption of technology a priority. Important lessons from these sites include:

- **Educational rationale should guide technology decisions.** Developing a technology plan—thinking through the goals for technology use at the local site and involving teachers in the planning process—is key to successful implementation.
- **Those wishing to invest in technology should plan to invest substantially in human resources.** Training, maintenance, technical support and time to learn to use the technology have proven to be constant and continuing, yet key expenditures. Recently, several states (e.g., Texas and Florida) have recommended that at least 30 percent of technology funds be spent on training.
- **Teachers cannot use technology without systemic support.** The roles of principals, other administrators, and the community are critical in fostering sustained use of technologies. Other staff, such as media specialists, can provide technical and motivational support for teachers in their building if time is allocated for them to do so.
- **When it comes to learning to use technology, "hands-on" training is more than a gimmick or motivator.** It is a necessity. Teachers must have the chance to make the computer (or camera or whatever) work, and gain confidence in their own competence, before they try the same thing with their own class.
- Access **to equipment is essential.** It is extremely frustrating for teachers to learn to use technology in a workshop, then return to a classroom where the technology is not readily available. Many programs are increasing teacher access to technology by letting them take the equipment home (e.g., laptops, summer loaner programs, etc.) since most teachers put in many hours at home grading, planning, and preparing. Putting technology in the hands of teachers—allowing them to see and explore how technology can help them do their jobs—can be an effective way of motivating teachers to learn about technology.
- **Although there are a number of models for training teachers and implementing technology, there is no one best way of using technology or of training teachers to use technology.** Districts are most successful when they have multiple and complementary training and support strategies.
- **Followup support and coaching is as essential to effective staff development as is the initial learning experience.** Teachers don't "learn it all" at a training session—even if it extends over several weeks. When they return to the classroom the unexpected inevitably happens. At this point, teachers need to be able to reach out for technical assistance and support.
- **Many technology-rich sites continue to struggle with how to integrate technology into the curriculum.** Curriculum integration is central if technology is to become a truly effective educational resource, yet true integration is a difficult, time-consuming, and resource-intensive endeavor.
- **When conditions are right—resources, time, and support are high-exciting things happen in technology-rich environments.** Today we are faced with the broader issues of how to move these lessons to the second stage of dissemination. How can these lessons be translated when resources aren't as rich? When teachers aren't as enthusiastic or energetic? Issues for policy consideration include the need to consider the development of products based on research and experience of experimental sites, seeding of more "real world" projects, and better dissemination of lessons learned.

SOURCE: Office of Technology Assessment, 1995 tive efficiency, and teacher professional development, *as appropriate*. The policy options in this report focus on the question of teachers' roles in accomplishing this goal, and on the advantages and disadvantages of selected legislative actions related to teachers and technology.

The array of technology for education is diverse, changing, and flexible, and these characteristics enable development of hardware, software, and learning environments that can suit special needs, allow new approaches to teaching and learning, strengthen teaching, and create excitement in the classroom. The broad and expanding range of educational technologies complements the diversity of the American education system. In the past, federal policy has often floundered on the enormous scale and differences that characterize American schools, compounded by the strong tradition of state and local control. In thinking about policy for technology, decisions can be made to allow for variation, change, experimentation and differing outcomes, and so strength can build upon strength.

Federal policy over the past decade has too often focused solely on generating funds for capital investment in hardware. Other policy initiatives have been diffuse and, until recently, there has been little focus on technology by the leadership of the U.S. Department of Education. Insufficient attention has been given to teacher preparation, development and support of learning tools and techniques, issues of connectivity, and the constantly growing demands on teachers' time. While costs of hardware will remain an issue, it is important to remember that technology capacity continues to increase at an astounding rate and that hardware costs often drop relevant to the power one purchases. While direct funding or other financial incentives are, of course, effective ways to demonstrate leadership and commitment, OTA concludes that, if the federal government wants to support the expansion and appropriate use of technologies in K-12 schools and colleges of education, federal policy must go beyond funding. Leadership; a commitment to research, development, and dissemination; an increased focus on teachers; and attention focused on issues related to the challenge of school access to the emerging electronic telecommunications infrastructure are equally critical.

OTA has identified a number of necessary components for taking advantage of learning technology and optimizing use of technology by teachers. These components are summarized in box 1-7 and discussed below.

Federal Leadership: Legitimizing, Funding, and Targeting Technology

If it wants to promote the appropriate uses of technology in elementary and secondary schools and colleges of education, the federal government can **move to fully legitimize the role of technology to enhance instruction, increase teacher productivity, create new teaching and learning communities, and support educational change.** Federal signals that technology is not only welcomed but needed in schools will strongly influence state and local decisions over the next five years. Until very recently, with little focus on the use of technology within the Department of Education, technology was an acceptable expenditure in many programs but was not held up as a tool for improvement. An important exception to this was the Star Schools Program, initiated by Congress in 1988, which has addressed a number of educational needs for students and, to a lesser degree, teachers, through emerging applications of technology.

The Goals 2000: Educate America Act (P.L. 103-277) called for creation of an Office of Educational Technology within the Department of Education. The need for high-level coordination of technology issues had already been recognized by the Secretary of Education in the appointment of a Director of Educational Technology in 1993. An office like this can **provide the much needed spotlight on technology, coordinate programs, and lead in evaluating and disseminating research result**s. Continuing to support this office, and seeing that adequate resources and authority are provided, will be critical.

A valuable related step is to **make the most of the national long-range technology plan to be**

BOX 1-6: Past Federal Efforts To Support Teacher Development

Although it is in the national interest to have a high-quality teaching force, the federal role in teacher preparation and professional development has been limited. There are exceptions: spheres where the federal contribution has been larger and more influential, such as teacher training in mathematics and science, and personnel preparation for special education, In general, however, the federal government has shown caution about becoming too deeply involved in an area traditionally considered a state responsibility, and until very recently has avoided even the suggestion of minimum federal standards for teacher education, It is the states that have exercised primary authority for teacher preparation, licensing, and certification, and more recently, competency testing. Substantial responsibility for preservice education also rested with universities and for inservice education, with local school districts.

In keeping with this limited role, **federal contributions for teacher training have been modest compared with overall federal spending for education.**

Purposes of Federal Involvement in the Past

The federal government became involved in teacher training for a variety of reasons. Often the impetus was a perceived crisis, such as threats to American competitiveness or widespread teacher shortages, In other cases involvement was an outgrowth of other federal commitments. The enactment of federal programs to improve education for the handicapped, for example, created new demands for specially trained teachers to staff these programs. Similarly, effective implementation of federal drug education programs required new training for teachers. Other motives for federal action stem from dissatisfaction with the quality of teacher education or with other aspects of K-12 education.

This diversity of motives resulted in programs that had various purposes, took various forms, and employed various strategies.

Impacts of Past Programs

Past federal programs had many positive effects on teacher preparation and professional development. It might be said that the federal government helped give credence to the concept of inservice education and professional renewal, through such programs as the National Science Foundation teacher institutes and the National Defense Education Act institutes and Teacher Centers,

developed by the Secretary of Education in accordance with Goals 2000. This plan could provide along-overdue strategy for the federal role in educational technology, not only in ED but across the government. It is crucial that the Secretary take maximum advantage of the directive in the law to join forces with other agencies to produce coherence and vision at the national level. Using all national agencies and programs wisely to expand, evaluate, and build upon knowledge in educational technology is a policy model that can also apply to federal programs affecting teacher preparation and the professional development of the current teacher force.

The executive branch is involving professional associations and citizen groups, as well as federal agencies and researchers, to develop a plan with foresight and credibility. An important caution, however, is that the plan must respect and build upon the extraordinary level of change occurring in technology capacity and the multitude of developing applications. The plan should be a framework for an environment of experimentation and learning, evaluation, and sharing of results. A plan of this nature could call forth rich results, opportunities to learn from problems as well as successes, and build respect for state and local expertise and decisionmaking.

Goals 2000 contains other provisions that could set the direction for educational reform for the next several years and could be used to leverage improved technology policy. A key provision

BOX 1-6 (cont'd.): Past Federal Efforts To Support Teacher Development

Although federal training programs never reached more than a small percentage of the total teaching force, this should not obscure the fact that many millions of teachers benefited from federally supported training. In some subject areas and specialties enough teachers were trained through federal programs to have a significant effect on instructional quality or teacher supply. Mathematics and science is a case in point. Even if the National Science Foundation institutes reached somewhat fewer teachers than the agency's estimate of half the math and science teachers in the nation, there were still enough trained to constitute a potent force for improvement within their discipline.

The federal government was also a major force in the growth of certain teaching subspecialties, such as special education, bilingual education, and instructional media. In a sense there was a chicken-and-egg relationship between federal funding and the need for specially trained teachers. On one hand, it was the power of federal mandates that created a demand for some subspecialties in the first place. On the other hand, federal intervention filled a void because the special needs of some children were not being met through traditional instruction or teacher preparation.

Federal aid also changed the composition of the teaching force. Scholarships, fellowships, and training opportunities broadened access to the teaching profession for students from blue-collar or low-income families and for minority individuals. Federal programs such as Teacher Corps attracted talented and energetic persons into teaching who might have pursued other careers.

Participation in federal training programs produced substantial improvements in the knowledge, attitudes, behavior, and career advancement of many teachers. At the school district level, federal funding sometimes provided the external stimulus needed to promote change. Federally supported training familiarized many teachers with instructional approaches that were once considered innovative, such as individualized instruction, interdisciplinary approaches, team teaching, and multicultural education. And, most significantly for this study, the integration of various technologies into the classroom—including audiovisual materials, educational television, and computer technologies—was hastened and encouraged by federally supported training.

SOURCE: Office of Technology Assessment, 1995, based on Nancy Kober, "Teachers and Technology. The Federal Role, " Office of Technology Assessment contractor report, May 25, 1994.

authorizes federal grants to states that develop "a systemic state-wide plan to increase the use of state-of-the-art technologies that enhance elementary and secondary student learning and staff development."31

In addition, states that submit an approved application will receive funds under Goals 2000 to establish state content and performance standards for student learning. Whether these standards will instigate the massive reforms desired by advocates will depend on what the standards contain and how seriously they are taken. **The *inclusion* of technology issues in these standards, however, could signal that technology is an appropriate tool for all core subjects, while the *omission* of technology could prove a genuine setback.** Although the federal government does not have the authority to dictate the substance of these national and state standards, the law established a National Education Standards and Improvement Council (NESIC) to review and "certify" the standards. If NESIC or some variant

31 Public Law, 103-227, 20 USC 5897.

BOX 1-7: Areas for Federal Policy

1. **Federal and state Leadership that articulates the value of integrated, technology-based teaching and legitimizes technology as a path to achieve educational goals.** This leadership will be meaningful to the extent that it is supported by commitments to fund and encourage technology use, and is linked to continuing research, development, and dissemination. It can also focus attention on the potential of technology for providing resources to improve the preparation of new teachers and as a valuable tool for the "just-in-time training and support" for professional development,

2. **Increased focus on teachers, both in training and in the field, including: time and money to allow teachers to learn to use technology, support for their professional growth, respect for the complex nature of learning and the many demands facing teachers today, and research on how technology affects teaching and school change.** Congress has taken some steps to promote increased technology use in schools, and greater support for teachers who use technologies. Technology planners in K-12 schools and in colleges of education can take advantage of such support to further their goals.

3. **Provisions to ensure that access to data and information, through services such as the Internet, are available to all teachers and students.** The special needs of education are likely to be overlooked or neglected unless they are built into federal, state, local, and private sector decisions on telecommunications regulation and funding over the next few years, Access to high-quality information and necessary resources may be today's measure of equity in education.

4. **Commitment to research, development, and dissemination that will advance technology use by and for teachers.** The development of powerful curriculum products, tools, and telecommunication resources is often beyond the capability of individual states, districts, or schools. The private sector may be able to play a greater role in developing new educational technology products than they have in the past, but some observers note that education may not be a promising enough market unless incentives are found to aggregate it.[1] Federal support may be needed to infuse the appropriate funding, expertise, and attention to standardization, evaluation, and dissemination that can facilitate school use of promising technologies and their applications. Furthermore, research is needed on teachers and technology use if these applications are to be used most effectively.

[1] The Software Publishers Association reports that the average elementary school spent $12,500 and the average high school spent $10,400 on software in the 1993-94 school year Software Publishers Association, *SPA K-72 Education Market Report* (Washington, DC: July 1994), Overall, the annual expenditures made by K-12 schools has been estimated to be approximately $1 billion, and software purchased by K-12 schools has been growing at the rate of about 20 percent per year Ronald E. Anderson, "The Technology Infrastructure of U S Schools," *Communications of the ACM, vol. 36, No 5,* May 1993, p 72,

SOURCE Off Ice of Technology Assessment, 1995

is supported, its criteria for certifying standards could include a review of whether technology needs and methods have been considered.[32]

Another very critical step that the federal government can take to provide both leadership and dollars is to **make the most of the opportunities available to support and encourage technology-related professional development in current programs, and the Improving America's Schools Act (P.L. 103-382), with its amendments to the Elementary and Secondary Education Act of 1965.** The Office of Education-

[32] Legislation has been introduced that would eliminate funding for NESIC (H.R. 977, H.R. 1045, S. 323, and S. 469, all in the 104th Congress).

al Technology will be well suited to lead a review of existing and proposed programs to ensure that they give fair consideration to technology-related expenditures and to determine whether there are program regulations, guidelines, and accounting procedures that either discourage expenditures for technology and professional development or have untapped potential to encourage them.

P.L. 103-382 also included a major **new Technology for Education Act** that could be the centerpiece of a stronger federal role in providing technology-related teacher development, ensuring greater access and equity in the area of technology, and demonstrating and disseminating several promising educational applications.

The federal government could **take several steps to achieve better use of programs and funding authorized under current laws. Federal regulatory actions could include establishing priorities or bonus points related to technology in competitive grant programs, issuing policy statements highlighting acceptable expenditures for technology and professional development where the law permits, and eliminating unnecessary nonstatutory restrictions on the use of funds for technology or training purposes**. A message from federal leaders can send a strong signal of reassurance to state and local educators that they can acquire and upgrade technology and, most important, train teachers in its use with no regulatory constraints.

Particular attention should be focused on the revised **Eisenhower Professional Development Program**, given greater emphasis in P.L. 103-382, which calls for a larger federal teacher professional development effort in several critical subjects. The Secretary of Education could encourage states, universities, and school districts to consider integrating technology into the various professional development activities supported under this program.

Other federal programs that should be examined include the programs for students with special needs that are a cornerstone of the federal role in education, particularly **Title I of ESEA for disadvantaged children (referred to commonly as Chapter 1), the Part B state grant program under the Individuals with Disabilities Education Act (IDEA) (20 U.S.C. 1400 et. seq.), and the Bilingual Education Act (20 U.S.C. 7401 et. seq.).** Together these programs channel almost $10 billion to states and school districts. Educational technology has become an important tool for delivering instruction to the children served by these and other special needs programs, yet teacher professional development has not kept pace.

In Chapter 1, for example, technology continues to be used primarily for drill and practice of basic skills rather than for the more promising and integrated kinds of teaching described in this report. Amendments to Chapter 1 in P.L. 103-382, and discussions about future policy directions in IDEA, are stressing improved program quality and professional development in these programs. For example, as justification for changes in Chapter 1, P.L. 103-382 states that, "Since 1988. . .[the nation has learned that] insufficient attention and resources are directed toward the effective use of technology in schools and the role technology can play in professional development and improved teaching and learning."[33]

Similarly, the 1994 Bilingual Education Act authorized $215 million in grants for activities intended to educate limited-English-proficient children and youth so that they would be able to "meet

[33] Public Law 103-382, Title I, 108, Stat. 3520, sec. 1001 (c)(6).

TABLE 1-4: Major Federal Policy Levers for Enhancing Teachers' Use of Technology and Teachers' Professional Development

Legislation or Program Level	Program	Goal	Funding[a]
Improving America's Schools Act (P.L. 103-382) (amending and revising the Elementary and Secondary Education Act (ESEA) of 1965 and several other federal education statutes)	ESEA Title I: Helping Disadvantaged Children Meet High Standards	Major activities supported grants to states for funding local improvement programs, family literacy, education of migratory children, others	$7,2 billion
	ESEA Title II: Dwight D. Eisenhower Professional Development Program	Supports professional development in core academic subjects	$359 million
	ESEA Title III: Technology for Education Act	Expanding access to and use of educational technologies, strengthening the technology infrastructure, supporting technical assistance and professional development	$40 million
	■ Star Schools	Improve instruction through grants to telecommunications partnerships for programming and facilities	$30 million
	■ Challenge Grants	Innovative projects, can include teacher training	$27 million
	■ National Activities	Regional technical assistance and teacher training consortia and other implementation activities	$13 million
	■ Product Development	Develop, produce and distribute technology enhanced instructional resources and programming for instruction or professional development	unfunded

	ESEA Title VI: Innovative Education Program Strategies	In the past, districts have spent funds on hardware and software purchases and professional development	*$347* million
	ESEA Title Vll: Bilingual Education, Language Enhancement, and Language Acquisition	To educate limited-English-proficient children and youth to meet the same rigorous standards for academic performance expected of all children and youth	*$350* million
	ESEA Title XII: Education Infrastructure Act of 1994	Ensure the health and safety of students through repair, renovation and construction of schools	$100 million
Individuals with Disabilities Education Act (20 U. SC. 1400) ❋ Eligible for reauthorization in 104th Congress		Educating children with disabilities	$3.3 billion
Goals *2000:* Educate America Act (P.L. 103-227)	Part C Leadership in Educational Technology, Office of Educational Technology	Encourage technology as a resource for providing instruction and professional development, and teacher training as part of technology investments	NA
	Part B National Education Standards and Improvement Council, Assessment, Development, and Evaluation Grants	Grants to states for plans, part of broader state improvement plans, to increase use of educational technologies for learning and staff development	$5 million (fiscal year 1994)
Revisions to Communications Act of 1934	Revisions will be important to pricing of telecommunications services	To be determined	NA

(continued)

TABLE 1-4 (cont'd.): Major Federal Policy Levers for Enhancing Teachers' Use of Technology and Teachers' Professional Development

Legislation or Program Level	Program	Goal	Funding[a]
Other Selected Areas and Activities			
Department of Commerce	Advanced Technologies Program - education activities		
	Public Telecommunications Facilities Program	Develop telecommunications facilities to serve local communities (distance-learning projects have been supported in the past)	$29 million
	Telecommunications and Information Infrastructure Assistance Program	Planning activities and demonstration projects for telecommunications networks	$64 million
National Science Foundation	Teacher Enhancement Program	Funds teacher training programs in math, science and technology	$101 million
	Teacher Preparation	Supports projects to improve undergraduate teacher preparation in math and science and technology	$18 million
	National Education Infrastructure for Networking	Demonstrates innovative applications of networking for education	$15 million
	Applications of Advanced Technologies	Funds research and demonstration in revolutionary technologies for education	$10 million
Public Broadcasting Act of 1967 (P.L. 90-1 29)	Corporation for Public Broadcasting	Support for development and activities in support of education and professional development	$285 million (estimated)

a FY 1995 appropriation unless otherwise indicated
SOURCE Office of Technology Assessment, 1995.

the same rigorous standards for academic performance expected of all children and youth."[34] Federal grants were authorized for projects using educational technologies, "if appropriate," among a range of other permitted activities. Furthermore a subpart of the Bilingual Education Act was devoted to professional development and, among the evaluation components required of recipients of bilingual education capacity and demonstration grants was a demonstration of "appropriateness of the program's staff professional development."

The recognition of technology and professional development in these legislative authorizations represents an opportunity to encourage states and school districts to use a portion of their program funds for additional professional development in forming the effective uses of technology for special needs children. However, without specific requirements in legislative language, it will be up to grant applicants or the Department of Education (in regulations or grantee requirements) to ensure that professional development and/or technology are foci.

Other programs, such as Star Schools, have as their primary purpose the use of technology to meet educational needs. These programs can continue to be leaders in experimentation, helping to add to the store of knowledge on how technology is effectively used.

OTA also finds that while great interest centers on advanced educational technology such as integrated curricula products and multimedia tools, **"small" technology is also needed to bring schools along the learning curve.** Telephones, voice mail, fax machines, calculators, television sets and VCRs, camcorders and editing tools all have a place in today's classrooms, but are often denied to teachers. In fact, providing a classroom telephone that puts a teacher in direct contact with a parent can facilitate the parent-teacher communication and parent involvement that many believe is essential to improving student achievement. Yet tools as basic as telephones are denied for a complex set of reasons, and cost is normally one of the smaller issues. Traditional methods of conducting school business, reluctance by principals to allow teachers more control over their professional lives, and general fear that teachers will somehow "misuse" telephones are frequently cited to researchers as reasons that telephones and other technology should not enter classrooms. **Congress may not be able to change such attitudes, but it or the executive branch could set the tone by taking steps to encourage the installation of telephones in classrooms.** As discussed earlier in this chapter, costs are likely to be a factor inhibiting the installation of technologies, whether small or large.

Research, Development, and Dissemination

Support for educational research, development, and the dissemination of research results has traditionally been viewed as an area of national concern, supported by federal funds. This is also true of such activities as they are related to educational technologies.

First, more and better information is needed on the effectiveness of various technology tools, and applications, including whether and how technologies work for teachers. Are some types of training or support more effective than others? Are they more effective for some type of teachers (by field) or by level (elementary versus secondary)? Some literature suggests that educational technology "takes off" when there is a critical mass of teachers committed to using it. Can this be substantiated? Experience has shown that teachers must be given time to learn and prepare, adequate technical and content support, and a supportive attitude from the principal's office, but surely there is more to be learned about teachers and effectiveness. Although some recent studies are beginning to investigate how the teacher's work life is changed by technologies, there has been little research on teachers as members of work groups, or

[34] Title VII of the Amendments in Title I of Public Law 103-382.

Research to date has looked at student achievement, comparing results of instruction with technology versus other methods. However, there are other important factors that make simple comparisons misleading.

on the breadth of activities teachers undertake. All these are fertile areas for federal research.

Alternatively, the federal government, states, school districts, and schools could leave the topic of effectiveness research to private sector product developers or form research partnerships with local university-based, research-oriented colleges of education. One disadvantage of a private sector approach is that product developers may use research as an opportunity for marketing. Publicly funded research may be more likely to point out both the positives and negatives of a new technology. Clearly, the education community needs additional exploration of research strategies that will lead to providing both accurate and timely results for use by adopters of new educational technologies.

Development of advanced integrated curriculum materials, projects and tools could be appropriate investments for the federal government, continuing along tradition of research and quality applications. Because the upfront investments are high, and state and local funds for development are limited, federal support has been important in the past. Many of the innovative technology applications reported on in this study have been supported by federal research funds, particularly the National Science Foundation.[35]

The work of the Department of Education, the Department of Energy, the National Technical Information Administration, the Department of Defense and its research agencies, and others has also been invaluable in creating new methods, new technologies, new materials, and new approaches with educational technology. Projects of this type can also enhance the link between teachers and the research community. Comparatively small amounts of money in the federal budget have had substantial impacts on technology use in schools.

Much of the focus and experimentation to date has been in the areas of math and science; work is needed in other subject areas. If Congress wishes to encourage the development of powerful, flexible learning tools and applications, federal support for continuing research and development will be necessary. **The development of the next generation of integrated curriculum projects can work hand-in-hand with proposed educational standards in all curricular areas, and could be undertaken as a national research priority.**

Congressional concern about timely development of new educational technology software was reflected in the 1994 Technology for Education Act's provisions on product development. Grant applications were encouraged that "promote the acquisition of higher-order thinking skills. .., convert technology resources developed with support from the Department of Defense and other

[35] For example, the National Science Foundation's Applications of Advanced Technology program.

federal agencies for effective use in the classroom; . . .[and] show promise of reducing the costs of providing high-quality instruction." No funds were appropriated for this program in FY 1995.

The federal government's seed money for product development can be said to have resulted in a sequential form of public-private partnership. A good example is the Kid Net project initially funded by NSF, further developed by TERC (a not-for-profit organization), and eventually turned into a marketable product that schools can purchase from National Geographic, which sells Kid Net as part of their profit-making company.

Alternatively, Congress could leave development of new education technologies entirely to the private sector. It is unclear, however, that K-12 schools, with their persistent constraints on resources, represent enough of a market for educational technology product developers. For example, the Software Publishers Association (SPA) estimates that K-12 schools spent an average of about $11,000 each on software in the 1993-94 school year.[36] In half the school districts surveyed by SPA, funds for software purchases came primarily from discretionary funds held by principals and teachers, from donations or business partnerships, or from school fundraising efforts. Possible tradeoffs between public and private sector approaches to new product development would be a good subject for further analysis.

Federal action can improve dissemination of research results. Experimentation with new technologies is only the beginning; teachers need to know what works and why. Dissemination of research results has not been adequately emphasized in the past, but it too can be enhanced and extended through technological means.

Educating New Teachers, Professional Development and Teacher Support

People preparing for teaching and teachers in the field face a vast and constantly growing set of demands for their time and attention. Mastering technology use may be only one goal placed before them. Yet using technology with facility is a daunting challenge for most people; teachers are no exception. One of the clearest findings of the OTA case studies and other research is that even very highly motivated teachers require substantial amounts of time—often over a three to five year period—before they feel fully versatile with a complicated new technology and are able to expand technology tools to fit their particular teaching goals. And finding time in the teaching day and year for training, collaboration, and "messing around with" technology is a bane of the profession.

A goal for states and localities that want their schools to function more effectively is to find ways to give teachers time for lesson preparation and learning, and support for continuing work. Exposure to new materials and resources, training in use of actual technologies, and development of new classroom patterns take time. They also require strong organizational support from principals, administrators, and colleagues. There is little point in acquiring hardware but making no provision for teacher development and support. Fortunately, technology itself offers some inherent solutions, if teachers can have equipment to use when they have time, and can be rewarded for learning. The use of telecommunications linkages to provide resources and opportunities for training is one of the most promising aspects of technology, but it cannot be a substitute for adequate time. As mentioned earlier, states with a strong commitment to effective technology use are beginning to allot as much as 30 percent of technology expenditures for teacher training and support. This includes the cost of substitute teachers as well as training resources.

The demographics of the teacher pool and the school population indicate a substantial increase in the number of teachers required just after the turn of the century. Teacher preparation has al-

[36] Software Publishers Association, *SPA K-12 Education Market Report* (Washington, DC: Author, July 1994).

ways been the province of states, colleges and universities. The federal government has played a limited role in the general area of teacher professional development, despite the fact that a large number of federal programs have been aimed at this issue and some have made an impact in specific subjects such as math and science (see box 1-6).

Prior federal efforts to improve teaching or increase the teacher pool reflect a scattershot approach. Preservice programs have included fellowships, scholarships, loans, support for certification efforts, and some direct training programs aimed at specific kinds of teachers or curricular materials. Current teachers have been exposed to summer and academic-year institutes, seminars, workshops, and one-time training sessions. Federal funds have provided institutional support to local school districts and schools of education to build their capacity. Strategies to magnify the effect of federal dollars have included targeting key teachers who are expected to train their peers or promote school change, training teams of teachers and administrators from one school, developing model training programs and, to a more limited degree, encouraging collaboration between school districts and universities.

A review of many other federal programs (see chapter 6) makes clear that in some instances, technology has been introduced to schools, but funding has been limited to the cost of hardware or software only, with no allocation for the preparation and support of teachers and other personnel. This strategy is a bad investment.

Congress could more definitively express its wishes to see adequate budgets for teacher support and training in future legislation or report language.

OTA concludes that an effective policy mechanism would be to **require that all applications for federal financial help that include technology show adequate budgets for high-quality support and preparation of staff**. This approach would remind anyone preparing an application how important planning is to assure technology will be well used; it will help to assure that teachers will be given support over the long term, not just when the technology is brought in the door.

States that are leading technology users have already adopted this approach. The Texas Education Agency recently recommended that districts allocate 30 percent of their technology funds for hardware, 30 percent for software, 30 percent to staff development, and 10 percent to maintenance. For the 1993-94 school year, the Florida legislature allocated $55 million for technology and $8.65 million for software, and required that schools seeking these funds set aside at least 30 percent for teacher training.

The importance of teachers for the effective use of technology, the need for expanding the population of teachers in the next decade, and the inclusion of teacher professional development in the national education goals suggest that **the time is ripe to consider whether the nation wishes to make a more direct and coordinated commitment of federal attention and resources for teacher preparation and professional growth.** Goal 4 of the National Education Goals specifies that by the year 2000, "the Nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century." Meeting this goal must surely mean competence in working with technology. **Policy decisions to meet this challenge could be carried out through the revised Eisenhower program, through other innovation programs such as the Fund for the Improvement of Post-Secondary Education, through broad initiatives such as the National Teacher Corps, or even through a national-level teacher certification.** A first step toward making this policy decision would be a review and evaluation of existing programs as recommended above, and consultation with professional societies, educators, parents, and others to identify appropriate federal actions.

Colleges of education remain generally low on the totem pole when value is assigned to undergraduate and graduate training. One force working to improve teacher preparation is a movement to raise standards for accreditation of teacher colleges; state and federal policy decisions that emphasize accreditation (or other outcome measures) are likely to encourage improvement. Awards and honors bestowed by professional education groups also contribute to higher status. **The federal government can play a role through its grantmaking activities, by encouraging and supporting technology applications when considering funding requests from schools and colleges of education**. In particular, education research centers and major graduate educational sites could be strongly encouraged to adopt teaching with technology, so that new teachers learn by example. In teaching, as in most other professions, the techniques modeled for new entrants by their own teachers are extremely powerful. If new teachers have not experienced the power of learning through technology-based tools, they will have less motivation to make the effort to master these tools themselves.

In addition to relying on the public sector for support, states, school districts, and schools that accept offers of hardware or installation from private sector companies (e.g., computers, wiring schools or providing other hookups to electronic information sources) could request or require that the companies also provide meaningful levels of initial training and continuing support for teachers. Some companies have provided such support on a short term basis (see chapter 4). Companies might be persuaded to agree with requests for more intensive support for technology-using teachers because technology-friendly teachers are likely to make more and better use of the technologies provided, and expand companies' markets. Schools may be reluctant to make such demands in the belief that the companies will be less likely to offer any assistance in the future, but the strategy might be worth trying and monitoring, as a means of providing more effective private sector support to schools.

While it is clear that diffuse, shifting federal teacher training programs that reach only a tiny fraction of teachers cannot change the profession, it is also clear that if a decision were made to intensify the emphasis on use of technology as a resource for preservice and inservice teacher development, efficiencies and improvements could be made in the overall ways these activities are conducted.

Access to the Emerging Information Infrastructure

In the early days of "computer education," great attention was given to the distribution of machines per capita. It is becoming clear that actual equity for technology today goes well beyond machine counts; in fact, machines are a necessary but not sufficient component of teaching and learning. Students in some classes may have access to machines, but nothing available from or through the hardware of any real value. Likewise, teachers need to be able to locate and retrieve information, collaborate with others electronically, and develop and share materials at their own pace and for their own needs. In the information age, access to necessary information may be the true measure of equity. Over the next decade, many individual, local, state, federal and business decisions will determine whether this resource is broadly available or greatly restricted.

At the present time, computer networks, electronic communities, software for searches and retrieval, and myriad other elements of an emerging information infrastructure are coming into use on a highly idiosyncratic basis. This takes advantage of technology capacity and caters to individual needs. It means, however, that teachers, schools, and students can easily miss the boat.

An intense debate is now under way about the role of education with respect to the emerging national and global information infrastructure. The policies that result from this debate may be the most difficult and important decisions of all. All sectors of the economy are struggling to come to grips with the new opportunities, products, and choices offered through these developing technologies and policies. The constantly shifting definition of the system, changing technologies, entry of new public and private participants, and the simple newness of the system mean that it is very hard to articulate policy choices for the near future, much less for a decade. Some conclusions seem clear, however:

- Having ready electronic access to information is likely to be necessary for schools.

  The costs of these services cannot be fully determined but will include hardware, software, connectivity, use of guides and helpers to effectively navigate the system, and fees for line access and use. How the nation's schools might afford ready electronic access to information, especially in a time of restricted or even reduced funding for education, is a major policy concern. School districts are facing huge costs just to bring their aging, dilapidated school buildings to where they meet basic standards. The General Accounting Office reports that $112 billion is required for the repairs, renovations, and modernization required to restore the nation's 80,000 public schools to good condition and to comply with federal mandates related to accessibility and safety regulations, for major building features such as plumbing and environmental conditions such as ventilation, heating, lighting, or physical security.[37]
- Intellectual property and privacy issues are important for schools, as they are for other groups.
- The K-12 education community, and the college-of-education communities are not well positioned to negotiate effectively in the open market or in the regulatory arena for rights and access, and are unlikely to have the funding, legal support, and bargaining power to protect themselves, unless there is intervention or guidance from state and national policymakers or the private sector.

Congress is considering a number of approaches for education and the emerging telecommunications complex. Some reflect the desire to apply the concept of "universal service," contained in the current legal framework for the broadcasting system, to schools. There have been suggestions to set aside portions of the information infrastructure for school and other public uses, and suggestions to provide special sources of funding for school connections to these system.[38] The education market could possibly be aggregated into a purchaser that generates substantial market clout. This model reflects the success of some states in centralizing purchasing of hardware, specifying arrangement for network connections, and specifying software from competitive vendors. For example, some states have regulated tariffs and established targeted subsidies for schools. Georgia, for example, through its state department of telecommunications, procures telecommunications services for schools at the same prearranged rate that state agencies pay.[39]

In California, the Industry Council for Technology and Learning worked with the Public Utility Commission (PUC) in developing a PUC Educational Telecommunications Plan for the state. When the commissioner, who originally did not know that the schools were not connected, met with the state's education agency, together they developed recommendations that overcharges to customers be channeled to education. This amounted to an estimated $40 million for telecommunications in the schools per year. As a part of this partnership, Pacific Bell pledged to connect every school in the state.[40] Currently, 18

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[37] U.S. Congress, General Accounting Office, *School Facilities: Condition of America's Schools* (Washington DC: February 1995).

[38] See, e.g., National Association of Secondary School Principals, Council of Chief State School Officers, National School Boards Association, American Library Association, and National Education Association, press release, Nov. 15, 1994.

[39] James Bailey Matthews, vice chancellor, Information Technology for the University System of Georgia, Atlanta, GA, personal communication, Mar. 13, 1995.

[40] John Cradler, Far West Education Lab, presentation to National Coordinating Council-Technology in Education and Training, meeting, Washington, DC, December 1994.

BOX 1-8: Organization of the Report

This first chapter highlights some of the main findings of the study and lays out several policy options for Congress. It also analyzes several issues related to educational access to the global information infrastructure, including rough estimates of cost of and possible financing strategies for developing a telecommunications infrastructure with various levels of school access. It addresses other issues relevant to emerging electronic information sources and teachers, such as intellectual property rights, confidentiality and privacy of records, and limits on student access to potentially obscene or harmful materials.

Each of the next five chapters begins with a summary of key findings from that chapter.

Chapter 2 discusses the potential of technology to support, enhance, and, in some cases, redefine the job of teacher. Based on the actual experiences of teachers as reported in interviews, site visits, case studies, and published research, the chapter examines why some teachers are using technology and how it is changing their classrooms and teaching methods. The chapter also describes how technology can help teachers carry out many of the administrative, productivity, and communications tasks associated with their jobs. Finally, the chapter considers how technology can be a resource for teachers' professional growth, whether through formal professional development courses or informal exchanges with colleagues and outside experts.

Chapter 3 provides a statistical picture of the presence and use of technology in schools today. The chapter examines the extent to which schools and teachers have access to various kinds of technologies, including computers, video resources, telephones, and networking technologies. It also looks at how schools actually use these technologies: how often, in which kinds of classes, and for which kinds of activities. Finally, the chapter examines state policies for technology access and use.

Chapter 4 analyzes the factors that influence how effectively teachers implement technology. The chapter examines multiple barriers limiting teachers use of technology and describes the resources currently available to support teacher use of technology. Building on case studies of promising practices, the chapter outlines some approaches that schools and districts are currently using to help teachers learn more about technology and draws some lessons about technology implementation from these pioneer sites.

Chapter 5 addresses the role of technology in the preparation of new teachers. It examines the treatment of technology issues in teacher certification requirements and teacher education reform proposals. The chapter analyzes the kinds of technology preparation currently provided to teacher candidates. Drawing on case studies of institutions that have made technology a priority, the chapter also describes some promising approaches for integrating technology into teacher preparation and highlights ways in which technology can improve the teacher preparation experience.

Chapter 6 summarizes the federal role in technology-related teacher preparation and professional development. It outlines current sources of federal support for these activities, the nature and extent of federal commitment, and new opportunities for federal leadership created by recent legislation. The chapter also examines past federal efforts to improve teacher training and promote technology, analyzing their impact and their lessons for future federal action.

states are using preferential telecommunications rates as sources for expanding the use of technology.[41] Legislation proposed (and in effect) at 'he state level speaks only to telecommunications access rates for intrastate service; any special rates for interstate service would fall within the authority of the Communications Act of 1934.

Congress may be left in a quandary as it considers how much it should do with respect to expanding the technological capabilities of elementary

41 Ibid.

Our children face a future in which technology will touch every aspect of their lives. Teachers want them to be ready

and secondary schools and colleges of education. Clearly, federal support for an *extensive* expansion of educational technologies, even if it were ideologically desirable, could be costly.[42] Because technologies are advancing so rapidly, there may never be an adequate, up-to-the-minute answer to the question of whether such investments are worth their cost.[43] Some states and local school districts may be able to take on the burden of investing in new educational technologies, even without a definitive answer as to the long-term payoff, but others will not have the resources. Given the federal budget deficit, and the tax burdens felt by American citizens in all localities, an extensive federal investment at this time may not be possible. The analysis in this report suggests strongly, however, that whatever investments in hardware and software are made, and at whatever level, with whatever sources of funds, the investments be made thoughtfully. In this case thoughtful investment will require that infusions of resources be accompanied by concomitant investments in the teachers who will be working with the students and the technologies.

The Department of Education is struggling to keep attention focused on educational access, as it works to define what products the education market needs and how schools can best participate in the emerging telecommunications system. Given the large federal role in interstate telecommunications issues, if schools are not to be left behind, Congress will need to pay close attention to this issue as it debates regulatory and subsidy measures.

Regardless of decisions made about funding, if unintended consequences of new technologies are not to hinder teachers' access to technology and telecommunications, policymakers must be vigilant regarding three additional areas pertinent to education and new information systems. These areas, discussed earlier in this chapter, are privacy, particularly with respect to the records of students, copyright law, and the tradeoffs between protecting children from inappropriate materials and untoward censorship of emerging networks. Protection of intellectual property products also requires effective education of the public about intellectual property rights. This education could begin in school as students, teachers and administrators are connected to online information systems.

CONCLUSION

Bringing about change in the diversified U.S. school system is a formidable task. With over 2.8 million teachers in the United States, and 3.3 mil-

42As discussed earlier, the costs of connecting schools, teachers, and studentsto emerging information technologies and sources are highly uncertain. Available rough estimates suggest the costs on a national basis could be minimal (for minimal interconnectivity) or they could be astronomical, relative to current spending by elementary sod secondary schools. In the 1992-93 school year, the National Center for Education Statistics estimates that public and private elementary and secondary schools spent $280 billion (U.S. Department of Education, Office of Educational Research and Improvement, National Center for EducationStatistics, *Digest of Education Statistics, 1993,* table 33, October 1993).

43 True costs will likely vary on both a national and local bases depending on what technology plans are developed, the state of current school infrastructures, technology costs at the time of implementation, and other factors.

lion estimated to be needed by 2003, any attempt to “retool” or provide the entire existing teacher workforce with new skills or knowledge will need to be done on a very large scale. Most teachers have many years of teaching experience (the median is 15 years) and, at a median age of 42, most attended school before computers were used in the classroom.

Teachers are an incredibly diverse group. Some already have experience with technology—computers at home, for example—while others have never even been shown how to “boot one up.” And some teachers are eager to experiment with new ideas even at the risk of failure, while others have little interest, energy, or time for experimentation. The great majority of teachers probably lie somewhere in between.

Technology has been viewed by a few as a frill, by some as a distraction, and by others as an intriguing but peripheral component of education. OTA finds, however, that technologies offer the ability to do many traditional things efficiently and quickly, and a way to encourage entirely new educational opportunities that may be of vital importance to the next generation of learners. If these learners are to make the most of the investments made in educational technologies, support must be given to the teachers who guide and encourage its use.

How can policymakers help to realize a vision of schools where teachers effectively and carefully identify, enlist, and use electronic and communications technology to improve learning?

OTA concludes that if the federal government wants to maintain or enlarge its involvement in this area, the linchpin of federal policy could be a set of initiatives that develop and support technology, and help teachers in their teaching and professional activities. When technology is effectively harnessed to goals identified by teachers, schools, states, and national policymakers, it becomes a vehicle for learning that is powerfully attractive.

One of the principal policy challenges for the next decade is to lead by example and by commitment. The experience of effective technology use in classrooms needs to be widely shared, evaluated and used as building blocks. Resources are needed to develop advanced learning products (hardware, software, curriculum materials, and tools focused on educational applications); both resources and farsighted regulation will be needed to make electronic communities affordable and well designed for schools. Effective policy and well-organized private sector involvement could create technology options that assure resources are equally available across the country, for all teachers, for all students, in all schools.

The Promise of Technology for Teachers 2

SUMMARY OF KEY FINDINGS

- Although helping teachers use technology well may be the most important step to helping students, there are almost no hard data on the impacts of technology on teachers; research has focused primarily on the implications of technology use for students. For information about the ways in which technology can help teachers, one must look to surveys, case studies, and reports from teachers who are accomplished technology users.
- The experience of teachers who are adept users of technology suggests that technology is not a panacea for all educational needs. Nor does it appear that there is one best way for teachers to use technology—just as there is no one best technology for every teacher to use. Instructional goals, teacher experience, subject matter or curriculum area, available resources and support, and student needs are all factors that affect teacher's technology use.
- Some teachers use technology in a traditional "teacher-centered" model of teaching, such as drill and practice for mastery of facts and content or as tutorials to supplement teacher-controlled activities. Other teachers use technology to support different, more student-centered approaches to instruction, in which students conduct their own scientific inquiries or projects or engage in collaborative activities, and the teacher assumes the role of facilitator or coach. The latter kinds of teachers are among the most enthusiastic technology users, since technology is particularly helpful in supporting this kind of teaching.
- Student enthusiasm for technology is a powerful incentive for teachers to use it. Teachers who are technology users often re-

port that technology can make learning more relevant to "real" life and more engaging and motivating to students.

- Some technologies offer a new set of alternatives to traditional pencil-and-paper testing by enabling teachers to record, review, and maintain records of student performance. For example, videotaping a student presentation not only provides a recorded demonstration of the student's understanding of the subject at that time, but also creates a "living" record of the student's progress throughout the school year that can be viewed and discussed by other teachers, the student, and parents.
- Simplifying daily tasks, such as recordkeeping, may be the most immediate way to involve teachers with technology. As teachers gain experience with technology, they often discover ways it can help them carry out their varied duties better, faster, or more effectively.
- Increased communication is one of the biggest changes technology offers classroom teachers. Technology, particularly new telecommunications options, can transcend the walls of isolation that plague the profession and allow teachers to converse with colleagues, the school office, experts in the field, parents, and others outside the boundaries of the school.
- Teachers who are leaders in telecommunications and other technologies are demonstrating how technology can be a vehicle for continuing formal and informal professional development. Many technology-using teachers report a renewed sense of professionalism when they take part in such activities, especially since they have little time for face-to-face collegial activity outside the classroom. Telecommunications can provide a means to give and receive support from colleagues and enable teachers to expand their knowledge in all content areas.

INTRODUCTION

New technologies[1] are becoming standard tools in American schools. Recognizing the growing role of technology in the workplace and in everyday life, school reform panels have stressed the need to provide students with skills to succeed in an information-based economy.[2] State and local curriculum frameworks have begun to incorporate standards for teaching students with and about technology. School districts are scrambling to keep up with ever more powerful hardware and software (see chapter 3) and are finding ways to integrate technology more effectively into instruction.

At the center of effective use of instructional technology is the teacher. For students to become comfortable and effective users of various technologies, teachers must be able to make wise, informed decisions about technology. However, technology is not a cure-all, nor is there one single technology tool or application that *must* be used by *every* teacher. As one group of researchers suggested, "If we abandon the idea that technology is a panacea—a magic cure for all that ails our educational system—we would expect that sometimes technology will make a difference and sometimes it will not."[3] **All teachers, however, should be confident in applying technology when and where appropriate.** Like their students, they should be "fearless" when it comes to using technology.

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[1] Although many people view educational technology as synonymous with computers, for the purposes of this report, the Office of Technology Assessment adopts a broader definition of educational technology that includes computers, VCRs, televisions, telephones, video and still cameras, audio devices, calculators and other hand-held devices, microcomputer-based lab equipment (such as sensor probes and measurement devices), videodiscs, CD-ROM, satellites, multimedia, and telecommunications networks.

[2] See, e.g., "What Work Requires of Schools: A SCANS Report for America 2000," the Secretary's Commission on Achieving Necessary Skills (Washington, DC: U.S. Department of Labor, June 1991).

[3] Jay P. Sivin and Ellen R. Bialo, "Microcomputers and Related Technologies: An Overview," a report on research covering 1986 through 1990.

How are teachers dealing with the influx of technology in schools? How and why do teachers use technology? In what ways, if any, can technology help teachers do their many-faceted jobs? Answering these kinds of questions is a complex, often frustrating task. Despite the central role of the teacher in educational applications of technology, there has been relatively little research on how and why American teachers use technology. Most research about educational technology has focused on the impact of technology on *students*; little attention has been given to its impact on *teachers*.

Furthermore, although teachers' experience and expertise with technology varies, the data that do exist about teachers typically focus on a special subset—the enthusiastic, pioneering teachers who are "accomplished" technology users. Specifically, two major surveys assessed the goals, attitudes, and activities of accomplished teacher users of technology[4] (see boxes 2-1 and 2-2). While these data do not discuss technology use by the average teacher, or by teachers in general, they do offer a vision of how technology can help teachers.

This chapter describes how technology can support, enhance, and in some cases redefine the job of teachers. The Office of Technology Assessment has derived the information for this chapter from multiple sources. These include the aforementioned surveys of accomplished teachers; interviews with and observations of teachers conducted for OTA under contract;[5] site visits by OTA staff to schools at every grade level across the country;[6] conversations with hundreds of teachers, administrators, and researchers at conferences,[7] meetings, workshops,[8] and over electronic mail; reviews of literature and evaluations of local technology implementation efforts from around the country; and OTA staff experience working in and with schools over the last decade. While much of the information from these data sources is anecdotal, descriptive, and qualitative rather than quantitative, together these sources paint a rich, multifaceted picture of teachers' experiences, often in the teachers' own words. And while the examples in this chapter are by no means all-inclusive, they indicate the varied ways that teachers around the country are using technology to carry out their jobs.

It should be emphasized that for teachers to realize the potential of technology as described in this chapter, certain basic conditions must be present, including adequate hardware, software, guidance, time, and a school climate that encourages

[4] Karen Sheingold and Martha Hadley, *Accomplished Teachers* (New York, NY: Bank Street College of Education, 1990); and Margaret Honey and Andrés Henríquez, *Telecommunication and K-12 Educators: Findings from a National Survey* (New York, NY: Center for Technology in Education, Bank Street College of Education, 1993).

[5] See especially, the following OTA contractor reports: Melinda A. Griffith, "Technology in the Schools: Hearing from the Teachers," October 1993; John R. Mergendoller et al., "Exemplary Approaches to Training Teachers To Use Technology," September 1994; Jerry Willis et al., "Information Technology in Teacher Education: Surveys of the Current Status" (Section 3: Survey and Interviews with Recent Graduates), March 1993.

[6] During the project (July 1993-December 1994), staff visited schools in California, Florida, Iowa, Kentucky, Maine, Maryland, Montana, New York, Tennessee, Virginia, Washington, Wyoming, and the District of Columbia. These sites were selected because teachers were actively using a variety of different technologies throughout the schools.

[7] For example, National Educational Computing Conferences, 1988 through 1994; New York State Association for Computers and Technologies in Education, November 1994; New York State Education and Research Network Annual Conference, September 1994; California Technology Users Conference, November 1994; and Florida State Information Technology Annual Conference, 1994.

[8] OTA Focus Group workshops, August 1994; OTA workshop on Technology Implementation Projects, "What Research Reveals About Teachers and Technology," Feb. 8, 1994.

BOX 2-1: How Computer Use Changes Teaching: Results of a Survey of Accomplished Computer-Using Teachers

In 1990, the Center for Technology in Education surveyed teachers who were "experienced and accomplished at integrating computers into their teaching. " The 608 teachers who completed questionnaires included teachers from grades 4 through 12 in all 50 states, drawn from a wide range of public schools and communities nationwide. '

The teachers who completed the survey did prove to be experienced computer users; most (73 percent) had used computers in their teaching for five years or more, some more than nine years. When asked about the effects of computers on their teaching, 88 percent of the teachers sampled indicated that computers had changed their teaching.

What kind of changes did the teachers report? First, many of the teachers indicated that, using computers, they expected more of their students (72 percent) and could present more complex material (63 percent). As one teacher wrote:

> I have been able to increase student productivity and enhance laboratory routines by implementing the computer as a lab tool. Students become better problem solvers and divergent thinkers when they are able to focus their lab experiments in their own direction using the computer.[2]

Second, many of the teachers said that the computers permitted greater individualization in their teaching (61 percent) and facilitated more independent student work (65 percent). Seventy percent of these teachers felt that the computers allowed them to give greater attention to individual students:

> My lectures are shorter on the topics covered by the software. I let the students set their own individual pace, and take responsibility for their own learning. It gives me more time to float around the classroom and interact with the students on an Individual basis.[3]

Third, many of these teachers reported that integrating the computer enabled them to spend less time lecturing to the entire class (52 percent), or more time to conduct work in small groups and one-on-one with individual students (43 percent).

> I have become more comfortable in the role of facilitator as opposed to a lecturer I am able to encourage children to find answers for themselves as opposed to giving them answers.[4]

Data from this survey also suggest that it took time-five or six years—for these teachers to master the use of computers as a multipurpose tool in their teaching. According to the researchers:

> ... [Five to six years] appears to be the point at which they [teachers] have a well-organized, workable set of practices. With this foundation, they can flexibly make choices about using new applications and about using familiar applications differently.[5]

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[1] Although inclusive of all regions of the country, the sample was not, nor was it intended to be, representative of all teachers or schools The researchers wanted to question those teachers who were known for and experienced in the use of computers in their teaching. To locate such teachers, the researchers contacted state and local technology directors, hardware and software vendors, professional organizations, leading educators and researchers in the field, and others and asked them to nominate teachers recognized for their accomplishments using computers in their teaching. The final sample of teachers was found to be representative of the demographics of public schools nationwide in terms of school size, region of the country, size of town or city, and ethnic composition of student populations. The sample had a somewhat higher representation of high schools and schools from lower income levels

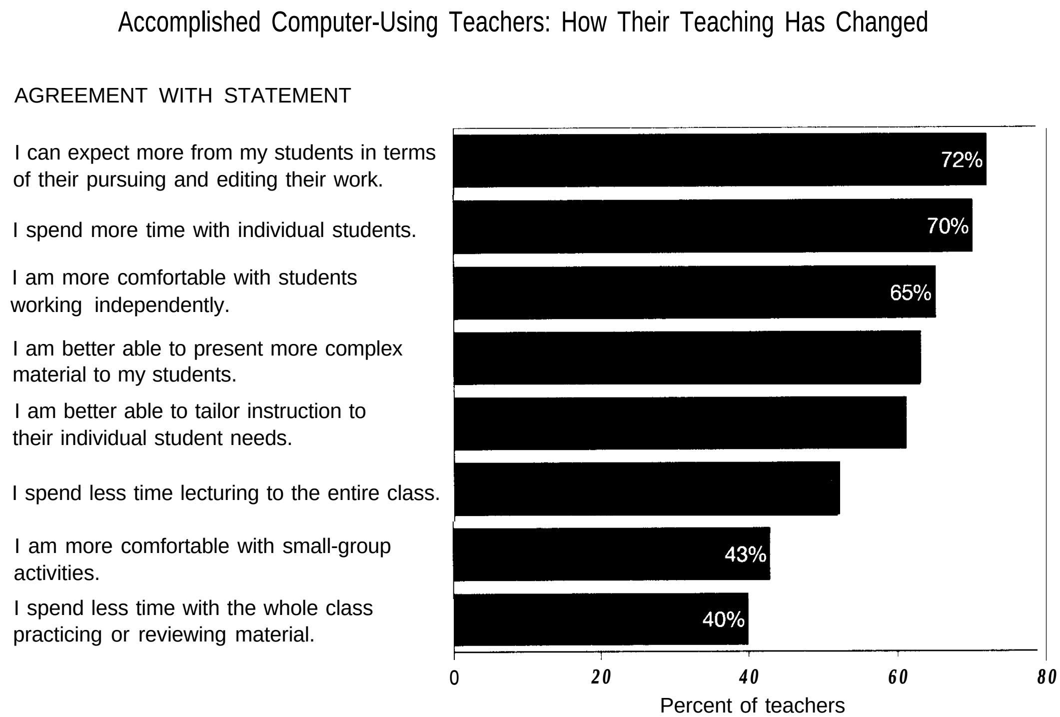
[2] See "Source" below, p. 14.

[3] Ibid , p. 15.

[4] Ibid.

[5] Ibid., p. 20

BOX 2-1 (cont'd.): How Computer Use Changes Teaching: Results of a Survey of Accomplished Computer-Using Teachers



NOTE: Based on the questionnaire responses of the 494 teachers (88 percent of the sample) who reported that computers had made a difference in their teaching

Although many of these teachers were highly motivated, and had developed impressive expertise in using computers in their classrooms, all of these teachers faced at least some barriers as they tried to integrate computers into their teaching The barrier most often cited by teachers was the lack of time to develop lessons that used computers Other significant barriers mentioned were problems with scheduling enough computer time, too few computers for the number of children, too few printers or other peripherals, inadequate financial support, and not enough help for supervising student use of computers

Why did these teachers persist with this challenging task? Of 29 possible incentives for incorporating computers into their teaching, the most highly rated by these teachers was that computers became "a tool for children that works for them in their learning, such as writing, analyzing data, or solving problems." Other incentives rated as important were that computers Increased the enthusiasm of the students and helped teachers make a subject more Interesting; these teachers also reported being motivated by their own professional growth, with a high share noting that they derived "personal gratification from the learning of new skills. "

SOURCE: Karen Sheingold and Martha Hadley, *Accomplished Teachers: Integrating Computers into Classroom Practice (New* York, NY Center for Technology in Education, Bank Street College of Education, September 1990) teachers to use these resources in innovative ways. The existence of these conditions is far from commonplace, as chapters 3 and 4 explain in more detail.[9] Chapter 5 discusses whether new teachers are being prepared to enter classrooms ready to use the technologies at hand. It should be stressed that the accomplished teachers whose experience is described in this chapter probably make up only a small percentage of all U.S. teachers.

TECHNOLOGY AND THE JOB OF THE TEACHER

It's February, and the 6th grade is at the beach.[10] This half of the school year, across all subject areas, 6th graders are working on an environmental theme. They have chosen four sites near the school, and every two weeks they return to those sites to compile data. Today they are working in small groups, collecting samples of plant life, water, and crustaceans to bring back to their science classroom for further analysis. They will store their findings in a computer database, which they can access and use in other classes, such as history or math.

On the beach, the teacher walks from group to group; using a hand-held, pen-based computer, she jots down observations about the students ***as they are learning****. She can record notes about a particular group's work habits or the individual learning styles of a student. The teacher can use the hand-held device to refer to previous observations, recall a student's particular weakness, and ask questions to see if that student has gained greater understanding of the material or the process. When the group returns to school, as the students conduct experiments and record data, the teacher can download her observations from the hand-held device to her desktop computer, which is connected to a schoolwide information management system. Other teachers can have access to the data, too, so if a student is having difficulty in a certain area, the teachers are able to address the problem together.*

Teachers must carry out many tasks to make the learning experience a rich one. They must guide and encourage students, provide varied learning experiences, keep track of student progress, and evaluate student learning. In reality, this means they must regularly find and organize information, create lesson plans, grade papers, maintain extensive records, and deal with a range of administrative duties. And, as with any profession, they must keep current with developments in their field.

OTA finds that technology can be a powerful tool for helping teachers with all the different parts of their job: enhancing instruction, simplifying administrative tasks, and fostering professional growth activities. The experience of some teachers further suggests that technology can help redefine the role of the teachers, in and out of the classroom.

Although teachers have long accomplished the manifold tasks required in teaching without technology, some teachers who have learned to integrate technology tools into their teaching have found them to be useful in ways they had not imagined. These teachers describe how technology makes it possible to meet current instructional goals or pursue altogether new goals. Some find that using various technologies allows them to teach in entirely different ways (see boxes 2-1 and 2-2).

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[9] Chapter 3 looks at the amount of technology present in schools today and teachers' access to various technologies. Chapter 4 explores some of the barriers that affect technology use by teachers, as well as some models and lessons for how schools can foster more widespread and effective use of technology by teachers.

[10] This is a fictional composite of various activities at sites visited by OTA in spring 1994. However, such projects do exist. For example, the Global Thinking Project at Georgia State University engages teachers and students in collaborative investigations of their local environments and in global discussions of environmental issues using a telecommunications network. The project is funded through the U.S. Eisenhower Higher Education program and the U.S. Environmental Protection Agency.

BOX 2-2: How Teachers Use Telecommunications: Results of a Survey of Teachers Who Are Telecom Pioneers

To understand better how telecommunications resources are being used in schools, in 1993 the Center for Technology in Education undertook a survey of K-12 teachers actively involved in using telecommunications. To find such a group, they posted online announcements on more than 50 educational, commercial, and state-run telecommunications networks. They also solicited respondents through mailing lists, conferences, state education departments, and professional contacts. Of those teachers who were contacted in this manner, 550 completed questionnaires.[1]

The teachers who responded were an experienced group (83 percent had been teaching for 10 or more years) and were heavily concentrated in jobs directly related to using technology m instruction, such as computer specialist or library media specialist. Most (82 percent) of the respondents reported using computers in their teaching for five or more years; on average they had been using telecommunications for professional reasons for more than four years. Almost all (91 percent) had access to a computer at home; 73 percent had access to a modem at home.

Teachers were surveyed about the kinds of professional activities for which they used telecommunications. The most frequently reported activities were those used for collegial exchange, including sending e-mail to colleagues (76 percent of teachers reported doing so) and posting questions or exchanging ideas on forums and bulletin boards (62 percent). A substantial number of teachers also reported using telecommunications for information retrieval, such as accessing databases that contained information relevant to students (51 percent) and databases of educational research (49 percent), downloading curriculum materials (44 percent), accessing libraries (39 percent), and accessing information for colleagues (46 percent). A quarter of the teachers responded that they used telecommunications for one of these functions every day. Fewer teachers reported using telecommunications for administrative tasks, such as planning meetings (34 percent) and obtaining schoolwide information (18 percent) or attendance records (8 percent), This may be because many of the schools in which these teachers worked did not have the network infrastructure needed to perform such schoolwide functions. For example, 45 percent of the schools did not have a local area network (LAN), and 43 percent of those with a LAN reported that it was restricted to one room.

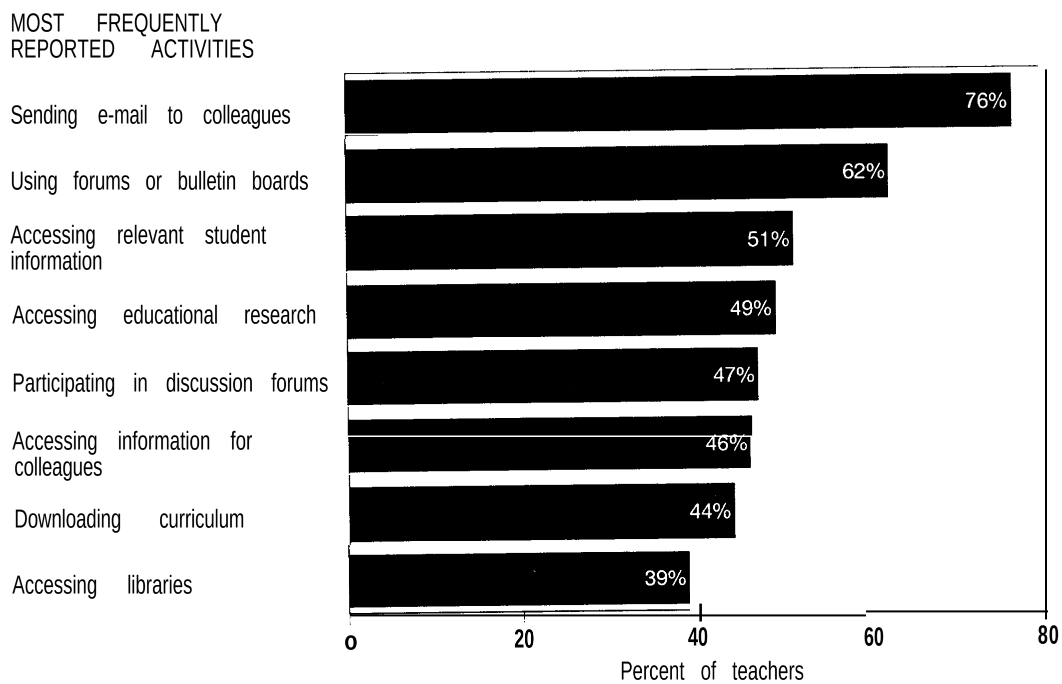
Teachers were also surveyed about the most frequent uses of telecommunications for student learning, which were less regular than teacher professional uses. The most frequently cited activities involved students' accessing services and databases, Including encyclopedias (57 percent of teachers used them with students), news retrieval services (54 percent), weather information (50 percent), Educational Research Information Center (ERIC) and other educational databases (48 percent), and scientific databases (39 percent). Classroom exchange projects were the other major use of telecommunications with students; these activities included pen pal exchanges (41 percent of teachers reported using these), scientific data collection and exchange (34 percent), and social awareness exchanges (33 percent). Far fewer teachers (about 7 percent) reported using telecommunications activities with students on a daily basis

[1] The authors of the study report that "across size, type of school, and ethnic and economic representation, the schools in our sample are comparable to national averages Although there is a trend toward more suburban schools m our sample than is the case nationally our economic data suggest that our sample does not represent more affluent communities. In fact, the percentage of schools which report that their students receive free or reduced-price lunches is slightly greater m our sample than is the case nationally"

(continued)

BOX 2-2 (cont'd.): How Teachers Use Telecommunications: Results of a Survey of Teachers Who Are Telecom Pioneers

How Teachers Use Telecommunications for Professional Activities



NOTE: Based on survey responses of *550* teachers who were actively revolved in using telecommunications

More than a third of these teachers reported that they served as telecommunications resource people and facilitators for their colleagues. Approximately one-quarter reported that they were the sole users of telecommunications in their schools; another quarter reported that several teachers in their schools used telecommunications for activities unconnected with each other. Only one-tenth of the respondents reported collaborating with other teachers in their building on telecommunications activities. More than half of the respondents described themselves as the principal catalyst for their schools' telecommunications activities.

The most frequently mentioned barriers to effective telecommunications use included insufficient telephone lines, lack of time in the school schedule, inadequate communication about school and district telecommunications activities, and lack of funds to cover the cost of network services.

SOURCE Margaret Honey and Andres Henriquez, *Telecommunications and K-72 Educators" Findings from a National Survey (New* York, NY Center for Technology in Education, Bank Street College of Education, 1993)

In addition, some teachers find that technology can enhance their personal productivity. And—perhaps the most exciting finding-some note that technology can help support their professional growth and enable them to continue to learn and improve their teaching skills.

There are many technologies available in schools today, with a wide range of applications to teaching and learning. **There is no single best technological medium that suits all teachers equally well.** Some teachers have focused on exploring applications of the computer; others a video camera or video cassette recorder. And, in growing numbers, some teachers have become enthusiastic about the instructional and professional applications of telecommunications technologies to reach out to others and to a wide range of resources.

Similarly, **there does not appear to be one best way for teachers to implement technology.** Different teachers and schools find different reasons and methods for using technologies. In the survey of teachers accomplished in telecommunications, many were using it to send electronic mail (e-mail) to colleagues (two-thirds of those surveyed); fewer (approximately 40 percent) used it for student pen pal exchanges.

USING TECHNOLOGY TO ENHANCE INSTRUCTION

Teachers use new technologies for the same reason they use books, worksheets, and other teaching tools—to help their students learn. Evidence from an array of studies indicates that technology in the classroom can have a positive impact on student learning, in terms of achievement in certain subject areas, development of skills, and attitudes toward school (see box 1-1 in chapter 1).[11]

RANKIN ELEMENTARY SCHOOL, TUPELO, MS

Teacher Kameron Conner incorporates technology into her classroom instruction when and where it makes sense. Here, a second-grade student records his voice as he reads from a book. When parents visit the class, they can hear their child reading and record a message back to the child.

Although early research tended to focus on "the computer" as an independent variable that somehow affected the learning process, **it is becoming increasingly clear that technology, in and of itself, does not directly change teaching or learning.[12] Rather, the critical element is how technology is incorporated into instruction.** In a review of research on computers and basic writing instruction, for example, the researchers concluded:

> . . . the most effective utilization of computer software in the basic writing classroom combines the best of writing instruction theory with a creative use of computer technology. Only well-informed, trained and caring composition

[11] See, e.g., C.L.C.Kulik~dJ.Kul&, "Effectiveness of Computer-Based Instruction: An Updated Analysis," *Computers in Human Behavior, vol.* 7, 1991, pp. 75-94; Ann D. Thompson et al., "Educational Technology: A Review of the Research," Association for Educational Cornmunications and Techology, 1992; J. Pisapia and S.M. Perlman, *Learning Technologies in the Classroom: A Study of Results* (Richmond, VA: Educational Research Consortium December 1992); Ellen Bialo and Jay P. Skin, "Report on the Effectiveness of Technology in Schools, 1990-92," Software Publishers' Association, Washington,DC. n.d.; Stanley Pogrow, "Learning Dramas: An Alternative Curricular Approach to Using Computers with At-Risk Students," in C. Wagner (ed.), *Technology in Today's Schools* (Alexandria, VA: Association for Supervision and Curriculum Development 1990); and Chery M. Kane, *Prisoners of Time,* Research report of the National Education Commission on Time and Learning. (Washington, DC: U.S. Government Printing Office, September 1994), p. 29.

[12] Ann D. Thompson et al., "Educational Technology: A Review of the Research;' Association for Educational Communications and Technology, 1992, p. 43.

BOX 2-3: "The Adventures of Jasper Woodbury"

In recent years, many researchers and educators have been trying to develop new instructional approaches that focus on helping students learn to think and reason about important, complex problems; many are finding that technology can be a valuable tool in implementing these new instructional approaches. For example, researchers in the Cognition and Technology Group at Vanderbilt University have developed a videodisc-based set of materials, "The Adventures of Jasper Woodbury, " that engage students in complex mathematical problem solving. Central to these materials is a particular theory of learning—a "constructivist" approach that emphasizes student opportunities to engage in in-depth exploration, evaluation, and revision of their ideas over extended periods. The mathematics content and theory are consistent with the kinds of revisions to traditional mathematics curriculum suggested by the National Council of Teachers of Mathematics (NCTM).[1] "(The Jasper" researchers have also focused on designing special environments that make learning meaningful to students by "anchoring" instruction in a real-life context. Each "case" or problem involves complex situations that require students to formulate and solve a set of interconnected subproblems. The essence of the series is a set of narrative episodes. In each story, the main character is faced with a complex problem to solve (e. g., computing the fuel necessary to fly into the forest to rescue a wounded eagle, or drawing up a business plan, using statistics, for a booth at a school carnival). Students are challenged to solve the problem using data presented in the story. Teachers are encouraged to have students work in cooperative groups to consider alternative solutions to the problems. A variety of supplementary and supporting activities allow teachers to use the materials in many different ways in their classrooms.

Video has been found to be key to the design of these instructional materials, in part, because of its capacity to anchor the problem-solving situations in real life situations. "The video is also important because it brings the world into the classroom in a manner that motivates students, and it makes complex mathematical problem solving accessible to students who have difficulties imagining complex situations by reading, " the researchers report.

Research about the effectiveness of the *Jasper* series indicates that, after a year of using the program, students who received Jasper-based instruction outperformed control subjects on complex mathematical word problems, as well as on planning and subgoal comprehension problems; they also demonstrated significantly improved attitudes toward mathematics.

[1] National Council of Teachers of Mathematics, *Curriculum and Evaluation Standards for School Mathematics* (Reston, VA: NCTM, 1989).

SOURCE. Office of Technology Assessment, based on Cognition and Technology Group at Vanderbilt University, "The Jasper Series as an Example of Anchored Instruction' Theory, Program Description, and Assessment Data, " *Educational Psychologist,* vol. 27, No. 3, 1991, pp. 291-315.

instructors will help to bridge the gap between technology and humanity.[13]

Certain applications, such as the approach taken in the video-based problem-solving materials in "The Adventures of Jasper Woodbury," look particularly promising (see box 2-3).

Although *Jasper* is just one example of how new ideas about teaching and learning can be im-

[13] M. Valerie-Gold and M.P. Deming, "Computers and Basic Writers: A Research Update, ''*Journal of Developmental Education,* vol. 14, *No. 3,* spring 1991, pp. 10-14.

plemented with technology, it also illustrates the difficulty of sorting out the “effects” of the technology itself. In this particular example, many design and implementation features-a theory of learning and cognition, particular mathematical goals and skills, varying methods and approaches for using the materials in the classroom with students—all combine with the technology to affect student learning. Additional research is needed to develop a deeper understanding of which instructional uses of technology are most effective and under what circumstances, and how teacher interaction with technology plays into this effectiveness.

While improving student learning is a central goal, technology-using teachers express enthusiasm for additional instructional benefits of technology that may or may not be reflected immediately in measures of student learning: bringing a wider range of resources to the classroom, motivating learners, providing new teaching tools, accommodating individual learning styles, and even redefining the role of the teacher. These applications-discussed in the sections that follow—are the most typically mentioned when technology-using teachers use words like “transform,” “relevant,’ “flexible,” and “motivating” in discussing why they use technology in their classrooms.

■ Bringing New Resources into the Classroom

As technologies have become more widely available, they have made it increasingly easy for teachers to access a broader range of materials they can use in the classroom. At the most basic level the copying machine has allowed teachers to make copies of articles, charts, or instructional materials from outside sources and share them directly with students. Supplementary computer tools—such as scanners or digitizing cameras—allow teachers to bring in outside sources, enter them into a computer, and customize assignments for students. For example, a teacher can bring a timely article from the morning newspaper into class, scan it into the computer in minutes, and

Telecommunications projects expose students and teachers to resources and people that might otherwise be inaccessible, often in ways that were unimaginable only a few yeas ago. For instance, the Global Schoolhouse project (above) connects classrooms using different technologies, such as Cornell University’s CU-See Me software, which requires telephones and cameras mounted near the computer so video conference participants can see each other on their computers.

have her students work on rewriting, editing, or adding research to the story on the same day. Students can browse interactively or conduct electronic research searches in CD-ROM databases, encyclopedias, or other reference works. Thus, not only do technologies allow access to a broader range of instructional resources, but they also offer students the opportunity to learn to use electronic tools to access information and develop research skills using the technologies they will face in the future.

Telecommunications creates even broader possibilities for transcending school walls and accessing a wide range of learning opportunities and resources. Today, computers with modems, telephone lines, and local or wide area networks enable teachers and students to explore worlds beyond their immediate reach, such as perusing the card catalog at the local library for a list of books on a research topic, sharing weather data with scientists on a network, or previewing software to see if it is appropriate for a particulargrade level.

Many of the teachers who access telecommunications networks do so after school or at night, on their own time and very often on their own dime—but they say it is worth it. For instance, a teacher in Arlington, Virginia, said that she pays for her subscription to America Online because communicating with a scientist at a national research lab is a great way to get ideas for student projects or to encourage students in their work.[14]

Teachers who use telecommunications resources particularly mention the ways it can “extend the learning environment” for students:[15]

- “Electronic networks bring real equality of education to all students. My inner-city students were learning and participating with private school students who have access to very specialized equipment. Through Internet, my students were unaware of the social status of these students. It was wonderful to watch them exchange scientific information with students they would be very uncomfortable with in a classroom.”
- “It has expanded our classroom . . . blown away the walls . . . filled us with a sense of possibility . . . made us less provincial . . . personally involved us with the nation and the world.”
- “We’re more keenly aware of a world outside the classroom, in the sense of being able to reach out to information resources and not operate in a vacuum.”

Telecommunications can connect students and teachers—sometimes instantaneously and simultaneously—to poets or politicians, musicians or religious leaders, university professors or researchers on a national supercomputer, or other students down the block or on the other side of the world. The number of these telecommunications-based activities is growing rapidly, in part because of teacher and student enthusiasm for the opportunity to collect, share, and evaluate their ideas, data, and writing with classes in other schools and states or even in foreign countries. Some of these links are initiated by individual teachers on a class-by-class basis. Increasingly, telecommunications-using teachers are finding that connecting to a “*listserv*”[16] gives them immediate access to classes sharing a common interest in a particular topic. For example, “GLBL-HS” is a listserv created by two New York teachers for teachers and their students interested in discussing world cultures.[17] Another listserv, called the “Noon project,” involves classes at different latitudes where students measure the shadow of a meter stick at noontime. Based on these measurements and the latitude of each site, the classes calculate the diameter of the earth.[18]

There are also a number of more extensive curriculum-based telecommunications projects using electronic networks. While many teachers have long used project-based teaching[19] and continue to do so without technology, many teachers are enthusiastic about what technology can add by extending the project beyond the classroom. These projects have typically been created with federal or private support to cover the costs of curriculum development, organization, and teacher support. Some projects, such as the AT&T Learning Circle, Kid Link, and the International Poetry

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[14] Bonnie Bracey, Ashlawn Elementary, Arlington, VA, OTA site visit, Dec. 21, 1993.

[15] Comments taken from educators who responded to an online request for information. Gloria G. Frazier and Daneen Frazier, *Telecommunications and Education: Surfing and the Art of Change* (Alexandria, VA: National School Boards Association, 1994), p. 33.

[16] *Listservs* are lists created on telecommunications networks for discussion of topics of common interest. Some are moderated, with the organizer guiding and framing the discussion, but others are unmoderated and more free form.

[17] *NetTEACH NEWS*, vol. 2, No. 6, Nov. 29, 1994, p. 7.

[18] TERC, “Review of Research on Teachers and Telecommunications,” OTA contractor report, Washington, DC, May 1994, p. 25.

[19] *Project-based teaching* refers to teaching activities in which students develop skills and understanding in the context of carrying out projects that require them to apply these ideas and processes.

Guild, center around writing and the humanities.[20] Most projects, however, focus on science and mathematics, reflecting initial developmental support from the National Science Foundation. They include Global Lab (see box 2-4), an environmental education curriculum primarily for students in junior high and high school; the National Geographic Society's Kids Network, which presents science topics to upper-grade elementary school children; Kids as Global Scientists, in which elementary school students around the world exchange, compare, and study weather data with each other and mentors; and the Weather Underground, a similar weather study project linking students throughout Michigan.[21] Projects such as these can supply the focus and boundaries for interaction and can provide teachers with the content, accompanying materials, organizational help, and technical assistance they may need to work telecommunications into their curriculum and lesson plans.

Students can "play" various instruments on the computer with MIDI (musical instrument digital interface) software, which increases not only the students' familiarity with instruments, but can enhance their understanding of the way instruments interact.

■ Developing New Forms of Instruction

Some teachers are creating new teaching tools with technology that facilitate new forms of instruction. For instance, a teacher who wished to give her students abetter understanding of music created a multimedia set of musical instruments the students could "play." Using Hypercard[22] software on her computer equipped with a CD-ROM to play sound, she designed her own instructional software around a set of musical instruments and the sounds they make. Each picture of art instrument has a "button" the students can click on to hear the instrument's sound. The students can play the "game" of recognizing the instrument by its sound only. It is not the same as having the real instruments in the classroom-a luxury most schools cannot afford-but the students can "play" the instruments on their own, and it is a lot more quiet. According to the teacher, the software has been extremely successful with her students. "I am already able to see how the children's increased familiarity with instruments carries over to the music appreciation class," she said. "They are beginning to understand why a composer might choose a certain instrument to convey a particular image or emotion."[23]

By encouraging students to use computers, video, and telecommunications in tandem with tradi-

[20] AT&T Learning Circles, based in New Jersey, discontinued its network at the close of the 1994-95 school year, KidLink is an international dialog based in North Dakota; and the International Poetry Guild is at the University of Michigan, Arm Arbor.

[21] Global Lab is based at TERC, Cambridge,MA; Kids Network, National Geographic Society, Washington, DC; Kids as Global Scientists, the University of Colorado, Boulder and Weather Underground, the University of Michigan, Arm Arbor.

[22] Hypercard is a software program designed to create multiple pathways for moving through a body of related material, allowing the linking together of information following an associative, rather than linear, train of thought.

[23] Rhonda Coleman, music teacher, as quoted in John Steinmetz, "What Are These Things Good For, Anyway?'' technical report for Apple Computer, Inc., 1993, p. 10.

BOX 2-4: Global Lab: Collaborative Research for Teachers and Students

The Global Laboratory (GL) Project, developed by TERC[1] and funded by the National Science Foundation, engages middle- and high-school students and teachers in collaborative, hands-on, project-based investigations of environmental phenomena. Global Lab enables teachers to implement in their classrooms an advanced form of science teaching that is experiential and process-centered and that goes beyond memorizing facts and canned lab experiments. A specially designed telecommunications network links classrooms around the world with data exchange and analysis capabilities. The network makes classroom collaborations possible on both regional and global scales.

In order to prepare students and teachers for collaborative classroom science, the curriculum uses a developmental approach that leads students from carefully supported, skill-building activities to more open-ended research investigations. The sequence is designed to introduce students to the process of real science, empower them with essential skills for "doing science, " and then direct them to their own hands-on, real world investigations. The preparatory phase of the Global Lab year is called "Building Investigative Skills, " and the investigative stage is called "Advanced Research. "

Students and teachers begin with a community-building activity in which classes send information about their schools and community to other sites. As they do this, they learn how to manipulate and navigate around the telecommunications software. For example, a class in the Czech Republic wrote:[2]

> Our town IS a very old one It was founded in the 13th century and has evolved under both Czech and German influences, The town IS known as the "Pearl of South Bohemia "There are however many factories with smoking chimneys and outflows into the rivers, so we have already had experience with ecological problems. So we would be very glad to help any research into some of them

A teacher in Hawaii describes her class's reaction to data it received from other Global Lab schools:

> The students located GL schools on the map. and looked up information about the schools in our cluster. During this time, my class got revolved with longitudes and latitudes and made some interesting discoveries about their perceptions of where certain cities were!

The GL curriculum emphasizes the process of science and leads students through a series of hands-on activities to introduce them to key aspects of this process, such as the importance and history of collaborative science; the need for calibrations, measurements, standardization, international units, and reproducibility; and typical sources of errors. Each class selects a local site to study environmentally over the school year, and they begin to assess its environmental health and quality. Students start with qualitative observations of their sites, based on their senses (e.g., what do we see, feel, hear, smell at the site?). Working first without quantitative tools, they soon begin to develop an appreciation for the need for scientific instrumentation.

At this point, the curriculum introduces students to low-cost, high-tech tools developed or provided by TERC, and then requires them to use these tools to conduct a quantitative analyses of their study

[1] TERC, based in Cambridge, MA, IS a nonprofit education research and development organization, dedicated to science and math, Since 1990, Global Lab has revolved over 400 classrooms from 30 countries around the world

[2] Except as noted otherwise, all quotes are all taken from Berenfeld, "Technology and the New Model of Science Education" (see "Source" below)

BOX 2-4 (cont'd.): Global Lab: Collaborative Research for Teachers and Students

sites. This model features an activity called "Environmental Snapshots. " At the same hour (solar noon) on the same day, Global Lab students around the world make an environmental profile of their study sites. They measure parameters such as light intensity, carbon dioxide concentrations, air and soil temperature, and soil moisture at their study site, then compile their data and exchange it with other schools. They compare findings with projectwide data and formulate research hypotheses to explain observed phenomena. The Hawaii teacher further describes the process:

> Then they finally chose which teams they would liketo work on. I asked the Engineering Team to be responsible for taking measurements of air temperature, humidity, amount of light using a luxmeter, and also a radiometer, to measure pH... and wind speed. Meanwhile, the Ozone Team watched the videotape on how to assemble their devices. The Audio Team began writing their introductions... the Art and Writer Team began musing about their study site. It was a pleasure watching and listening to them comparing notes, discussing their work.

Students and teachers are then prepared to begin the project's second phase, Advanced Research Each classroom begins an in-depth investigation at their site in one of five research fields: including air and water quality, environmental chemistry, ionizing radiation and stratospheric ozone, and biodiversity and field explorations. A class in Texas explained their choice:

> Our classes chose Environmental Chemistry because we are concerned about the results of local industry and agriculture in our water, soil, and air Also, we would like to know if the recent flooding has affected the chemical [balance] in these areas.

The students discuss their work online with other schools and are encouraged to tap into local resources, outside scientific collaborators, and scientists from TERC. After conducting their investigations, the students in each classroom prepare a research report and then conduct "peer reviews" 01 other students' reports. An important part of the curriculum is teaching students about the ethics 01 science and the need for and nature of peer review.

Global Lab presents a challenge to many teachers. Often, participating teachers are learning content and technology use alongside their students. Furthermore, the open-ended, inquiry-based environment is different from the practices of many teachers. To help teachers make the transition to project-based pedagogy, Global Lab provides them with tools, materials reinforcing the concept of contextual relevance for student learning, a curricular framework, guidance for engaging a class in this model of scientific inquiry and collaboration, and, perhaps most important, online support. A Massachusetts teacher said:

> It's helped me focus more on the research process and the scientific thinking process, whereas before I think I'd gotten into the rut, having taught 25 years, of just giving them activities, having them fill out the sheets, and that's it. So this has forced me to start them thinking about hypothesis and guessing and thinking about what makes an experiment valid, and all the variables that could be in the experiment that might affect the data.

A Texas teacher admitted:

> The thing was that starting into this project, nobody knew anything, including myself. We had no idea what had to be done to study the problem we elected. Everybody had to go out and research it, and it turned out that Instead of learning it out of a textbook or being lectured about it, we were doing everything by trial and error, step by step. And to me it was more real science than what you normally get in a science class. I've learned more this year than probably in 13 years of teaching science.

(continued)

BOX 2-4 (cont'd.): Global Lab: Collaborative Research for Teachers and Students

Although there has been no formal research into the impact of the Global Lab model on teachers, preliminary evaluations revealed a great variety in the way teachers implemented Global Lab in their classrooms, These ranged from afterschool science clubs to a full science course,

> It is our core curriculum and from it we build other subjects, When we study water in Global Lab, we study water in history, its relationship to wars, and so on, how cities are created on it, We use it to write for English and we study English from it, We take all our field trips connected with it.[3]

As a project pioneering new teaching paradigms, Global Lab experiences suggest that giving curriculum support based on a developmental model can encourage teaching with collaborative, hands-on science investigations, When such pedagogy is enhanced by telecommunications, innovative software and hardware tools, and online collegial and expert support, this approach to teaching science reflects the kinds of relevant, inquiry-based scientific study recommended in the emerging national standards recommended by the science education community [4]

[3]See "Sources" below, Tinker and Berenfeld, p. 15.
[4]See, e.g., American Association for the Advancement of Science, *Benchmarks for Science Literacy (New York, NY:* Oxford University Press, 1993), and National Academy of Science, *National Science Education Standards* (Washington, DC National Academy of Science, 1994)

SOURCES Office of Technology Assessment, 1995, based on Boris Berenfeld, "Technology and the New Model of Science Education: The Global Lab Experience, " *Machine-Mediated Learnmg,* Vol. 4, Nos. 2&3, 1994, pp. 203-227, Barbara Tinker and Boris Berenfeld, "Patterns of Use Global Lab Adaptations, " *Hands-On/,* fall 1994, vol. 17, No 2 (Cambridge, MA TERC), pp. 14-15

tional materials, such as textbooks and other print or library resources, teachers can also give both their own lessons and student assignments more content and depth (see box 2-5). For example, in the social studies classes in Montgomery County, Maryland,[24] the teachers have been provided multimedia "MacPacs,"[25] to develop lessons based on texts, photos, TV or film footage collections on videodisc, or other powerful content that cannot be found in other media. Teachers also require that their students use these resources to create multimedia reports. Instead of the traditional approach to written reports ("use a minimum three different print sources and only one from the encyclopedia"), a teacher can suggest that students include clippings scanned in from a newspaper, maps, pieces taken from primary sources or family journals, photographs, references from the CD-ROM encyclopedia, or text with highlighted words that correspond to a student-created glossary, in addition to the other traditional research materials. Students thus must extend their research to include a variety of information sources; draw upon multiple ways of representing events, perspectives and interpretations; evaluate which materials work best for the presentation required; and then synthesize this material into a cogent multimedia message.

For example, for a report on Martin Luther King, Jr., a teacher in Kentucky has her high school students view a full-motion videodisc segment of the civil rights leader delivering his "I

[24] Linda Spoales, social studies resource teacher, Montgomery County, MD, OTA site visit Dec. 14, 1993.

[25] The "MacPaC" workstations each include a Macintosh LC Computer, a CD-ROM drive, a level III videodisc player, and a passive-matrix LCD display panel (for overhead projection of the computer screen). Each department also has a 3 I -inch television.

Have a Dream" speech.[26] Powerful as the speech is, it takes on additional impact when the student searches other video materials and discovers pictures of segregated lunch counters or water fountains with "Whites Only" signs, views film segments of speeches by other civil rights leaders and segregationists, reviews documents that support Dr. King's statements, and examines evidence in contemporary news articles that suggest whether or not his dream has been met. **The process is as important as the product, as students develop valuable skills in finding, evaluating, organizing, and communicating many types of information using new technologies as well as traditional research materials.** Although students could go to a library, read books, watch videos, and interview people, technology has the means to bring together all those original source materials in an easily accessible place—such as a videodisc or CD-ROM. Students may not otherwise have access to these kinds of sources. Some suggest that this is what using the technology can do best: give teachers the chance to ask and students better ways to find answers to "different questions, richer questions, questions that make kids think."[27]

By encouraging students to use a variety of technologies--such as video-to supplement the use of more traditional materials, teachers make both their lessons and the assignments more meaningful.

■ Motivating Learners

The nature of new technology-based resources suggests, and discussions with teachers confirm, that many technology-based classroom activities can be motivating to students. Some teachers report that many students become so involved in what they are doing with technology that they arrive before the firstbell and leave after the last bus. These teachers suggest that technology can be a key vehicle for stimulating learning, primarily because it creates environments and presents content in ways that are more engaging and involve students more directly than do textbooks and more traditional teaching tools.[28] Many instructional designers have suggested that the interactive capacity of new technologies-wherein children can actively interact with information and receive feedback on their questions or answers-contributes to its motivating effects.[29]

For example, asocial studies teacher in Montgomery County, Maryland, uses a multimedia station (which includes a videodisc player controlled by a computer using Hypercard software) in class; where teacher questions were previously greeted with silence, high school students now participate actively in class discussions. The multimedia lesson converts her lecture into more of a demonstration or slide show wherein she can easily show maps, charts, graphs, primary source documents, and video clips of news or historical footage. The computer technology allows the teacher to stop, backup, go forward, or skip to another "file" of images as students ask questions. This teacher was particularly impressed with the level of in-

[26] Debbie Hall, Shelby County High School, Shelbyville, KY. OTA site visit Apr. 18, 1994.

[27] David Mintz, National Center on Education and the Economy, personal communication, August 1994.

28 Thompson, op. cit., footnote 12, pp. 11, 68.

29 See, e.g.,David Thornburg, "Killing the Fatted Calf," *Electronic Learning* (New York, NY: Scholastic, lnc., September 1994), pp. 24-25; Richard Ruopp (cd.), *LabNet: Toward a Community of Practice* (Hilldale, NJ: Lawrence Erlbaum Assoc., 1993).

Teachers have found that students working together in small groups using technology are often more motivated and take greater responsibility for their learning.

volvement and interest this approach generated in students; she reported that they ask more questions, seem less afraid to speak out in class, and were even talking about it with their parents at home.[30]

Another example of the motivating effects of technology is described by a teacher in an alternative high school who reported that he used a software simulation program as both learning tool and behavior motivator for his class of ten 16- to 18-year-old boys. These students, referred from their regular schools and placed in the alternative school as a last chance before placement in a more restrictive educational setting, were often unruly and needed to develop social skills as much as they needed the academic skills they had missed in their earlier schooling experiences. Engaging this group was a challenge; yet, almost all were enthusiastic when presented with a science activity using simulation software. According to this teacher, his students loved working with "The Great Solar System Rescue";[31] working in teams as "experts"—meteorologists, astronomers, geologists, and space historians-they were challenged to find lost probes in the solar system. Working with the packet of expert material provided in the software and analyzing visual clues from the videodisc engaged their interest and focused their attention, and they learned about the solar system in the process. When one student became disruptive in class, his punishment was not being allowed to participate with the team for several days. The teacher said it was one of the most effective behavior modification techniques he had ever used.[32]

Some teachers contend that their students are more motivated and take greater responsibility for their learning when they are engaged in technology-based activities that require them to create and share content with each other. For example, in the Global Exchange weather-mapping project, middle school students work in groups of two or three to become "experts" in specific areas of local weather. The student "experts" collect data using Internet resources such as weather text and imagery, electronic dialogues with local scientists, book research, and other information. The teacher observed a higher level of motivation among students on the Internet compared with students not using telecommunications. "I could see the kids in the Internet classroom were more motivated to learn the material because they knew they would be sharing it with other kids their own age," she said, "and I think that the idea of sharing it with their peers was a . . . very good motivation for them."[33]

■ Individualizing Student Learning

Teachers who use technology also report that it can be used to help them individualize instruction. This has been one of the greatest appeals of integrated learning systems, computer and software

[30] Spoales, op. cit., footnote 24.

[31] "The Great Solar System Rescue," Tom Snyder Productions, Cambridge, MA.

[32] Robert Martin, BOCES, West Nyack, NY, personal communication, November 1994.

[33] Nancy B. Songer, "Knowledge Construction Through Global Exchange and Dialogue: A Case of Kids as Global Scientists," University of Colorado, Boulder, 1994, p. 30. Global Exchange is part of a larger project called "Kids as Global Scientists."

BOX 2-5: "Dear President Hoover"

In a Kentucky high school history class, the teacher instructs her students to write a letter to President Hoover to try to convince him that the Depression is not over. Before class, the teacher goes to the school library and checks out a videodisc player and a videodisc, called *History in Motion,*[1] for her students to use during class. For research to support arguments in their letter, the students can watch the videodisc to get a feel for the era in which Hoover was president.

The students use technology to see history as it happened: video clips of "flappers" dancing up a storm, followed shortly afterward by unemployed people on bread lines. One student takes the remote control and replays the sequence, freezing the frame on the bread line and confirming with another student that "this is the same decade?" It is the student's ability to access at the touch of a button the image of a bread line, the teacher says, and also to replay and discuss meanings of this powerful image, that points to the real difference between technology-based resources and print. In a textbook, the bread line doesn't shuffle forward while students watch the pained expressions on the faces of real people reaching for food.[2]

The teacher also has *Time* magazine archives on CD-ROM in her classroom so students—working in teams of three or four—can peruse and download articles that give credence to their claim that the Depression is not over. The availability of a product such as the *Time* CD-ROM not only provides more information but gives the teacher more opportunities to ask different questions, questions that challenge the students to investigate a topic in greater depth and think about the implications of the information they are now able to access. Students can also read other students' letters from previous years' classes and use any typical resources, such as textbooks, to prepare the assignment. This history class-combining traditional and technology-based approaches to research, communication, analysis, writing, and collaborative learning---connects the students to new resources and information in a way that not only captures their interest, but appears to encourage and support their participation in learning.

[1] *History in Motion* is published by Scholastic Software, New York, NY.
[2] Debbie Hall, Shelby County High School, Shelbyville, KY, OTA site visit, April 1994.

SOURCE: Office of Technology Assessment, based on Shelby County High School, Shelbyville, KY, site visit, April 1994

systems that correspond to curricula[34] and can be presented to each student in a class based on his or her abilities. The student can work on the material---often called "drill and practice' '—until reaching a level of mastery, at his or her own pace. Reports produced by these systems give the teacher a record of what areas were most difficult for each student, so that extra assistance can be given in those particular areas where the student needs help.

Technology has been extremely helpful in revolutionizing individualized instruction for special education students, many of whom are now being served in regular classrooms.[35] Hardware, soft-

[34] Curriculum refers to the courses offered by an educational institution (plural, curricula). Most schools have prescribed curricula teachers must follow throughout the school year and on which students are tested as the basis for passing a course or getting credit for it.

[35] Special education programs serve children with disabilities that include autism, deafness and hearing impairments, mental retardation, orthopedic impairments, other health impairments, serious emotional disturbance, specific learning disability, speech or language impairment, traumatic brain injury, and visual impairments. The Education for all Handicapped Children Act (Public Law 94- 142), renamed the Individuals with Disabilities Education Act (IDEA) in 1990, guarantees that children with such disabilities be served in normal classroom settings to the maximum extent possible.

ware, and assistive devices can help special education students progress in their learning and communicate their knowledge to others in new—and accessible—ways. For example, scanning devices convert text into speech so visually impaired students, in particular, can hear the content and respond to questions. An expanded keyboard with extra large keys or a touch-sensitive screen attached to a computer monitor are alternative input devices that help students with motor control difficulties use the computer without struggling with a mouse. Even a word-processing program with a spell-checking feature can ease the frustration for students who have difficulty with handwriting or spelling so they can progress to deeper levels of understanding the subject matter. As even more devices are developed to enable special education students to learn in innovative ways, it is hoped that teachers will be better equipped to provide appropriate instruction.[36]

Some technology tools, like the Algebra Tutor,[37] enable a teacher to track the paths a student takes to reach a solution to a problem, helping the teacher understand where the student is confused and needs help. Other applications such as TextBrowser,[38] word processing, and databases, can provide a "window into the student's thinking, inquiry, and problem-solving processes (giving) teachers access to students' misconceptions, the ways in which they sort and categorize information, the relationships they form among ideas, and the conjectures they make."[39]

While this look into the mind of the individual student is enlightening, it remains a nearly insurmountable challenge to find ways to draw upon this insight and work with each individual student in a class of 20 to 30 students, all needing the teacher's attention (see chapter 4). Some teachers report that using technology can allow them to structure their classroom activities so that students work more independently, sometimes in small groups. This may allow the teacher more flexibility to organize time to better meet individual student needs. While there are examples of how some teachers work with limited availability of technologies, clearly a more systematic understanding is needed of the factors that lead to success in such situations.

For example, in some cases, teachers have used technology as a tool for setting up activities in which students work in teams where their roles as members of the team are designed to draw upon their personal strengths and interests, to help them find areas where they can succeed and develop self-confidence. For example, in a school in San Diego[40] the students create adventure games for projects called "Microworlds." Based upon ancient cultures, games such as "Exploration in the New World in the 16th Century," are created using Hypercard. Teachers organize students into teams of researchers, graphics designers, project managers, programmers, and so forth; as students develop their budding expertise in these areas, they are

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[36] See, e.g., Thomas Wall and Jessica Siegel, "All Included: Inclusion of Special Education Children in Regular Classrooms Cannot Happen Without Technology," *Electronic Learning*, vol. 13, No. 6 (New York, NY: Scholastic, Inc., March 1994), pp. 24-34; also, Carol S. Holzberg, "Technology in Special Education," *Technology and Learning* (Dayton, OH: April 1994), pp. 18-21.

[37] "Algebra Tutor" was developed by John R. Anderson, Carnegie Mellon University, Pittsburgh, PA, with funding from the National Science Foundation, Washington, DC.

[38] D.M. Kurland, "Textbrowser: A Computer-Based Instructional Management and Assessment System for Language Arts Instruction," Newton, MA, Education Development Center, 1991.

[39] Barbara Means, John Blando, Kerry Olson, and Teresa Middleton, SRI International; and Catherine Cobb Morocco, Arlene R. Remz, and Judith Zorfass, Education Development Corporation, *Using Technology To Support Education Reform*, report for U.S. Department of Education (Washington, DC: U.S. Government Printing Office, 1993), p. 69.

[40] O'Farrell Community School, Center for Advanced Academic Studies, San Diego, CA. Based on presentation by Roland L. Garcia, Educational Technologist, at Society for Technology and Teacher Education Conference, San Diego, CA, March 1993.

called upon to teach others and contribute to the success of the project as a whole.

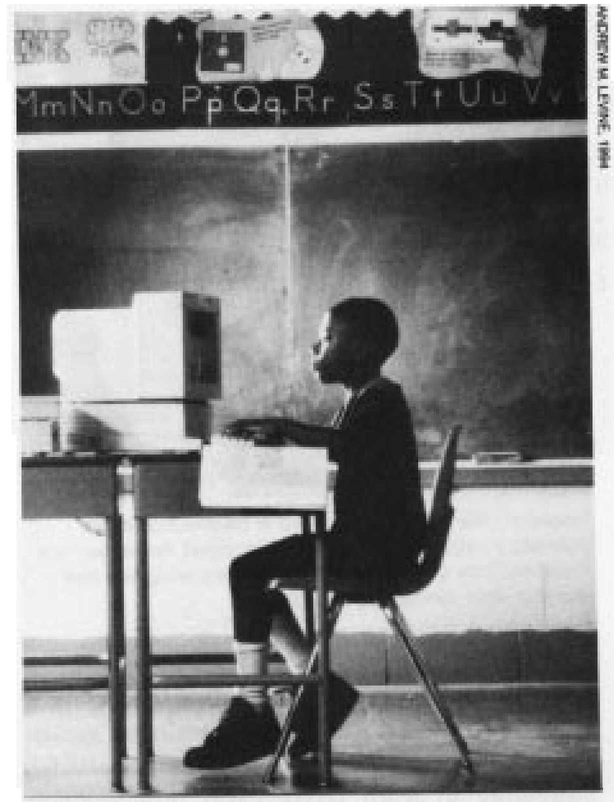
■ Redefining Teachers' Roles

When technology is integrated into the curriculum in a comprehensive way, and when teachers feel comfortable and confident about using it, **myriad changes occur that may ultimately redefine the roles of teachers. One** teacher echoed the opinion of many when she said: "I've gone from being the 'sage on the stage' to the 'guide on the side.'"[41] While some teachers have always taught in this way, others report that the change to a coaching, facilitator role can be daunting, especially when it requires them to venture beyond the teacher-centered lecturing or presentation model they experienced as students themselves or in their teacher preparation. Nevertheless, many who take on these "new" roles find the change is welcome, profound, and often necessary.

A teacher in the National Geographic Kids Network project summed it up this way:

> ...1 no longer spend most of my time standing in front of my class and lecturing or having the students read from a textbook. I have become a facilitator, stage director, resource manager, master learner, discussion leader, observer, and evaluator. For me this change has been refreshing, enlightening. and long overdue. My students too have changed. There are no longer textbooks or tests with right or wrong answers. They have become collaborators and teachers. They have become scientists making predictions, developing hypotheses, and analyzing data. And they spend their money buying school pencils, folders, and banners to send to their pen pals.[42]

Teachers at the Open Charter School in Los Angeles found that their roles were shifting as technology integration took over the school. The



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Some teachers use technology to tailor instruction to an individual student's needs or to structure classroom activities so students can work more independently.

Open Charter School received enough technology to make available one computer for every two students. One teacher described the change she has gone through as she has grown more comfortable in using technology:

> I don't do things in the same way that I did them before. I have had to become very inventive when looking for ways that I think the [technology] tool fits best for children. My goals changed, because I looked not necessarily at the outcome, but the process by which they were getting there.[43]

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41 Bonney Bracey, Arlington Public **Schools, on "The Digital Classroom" WORLDNET television program, Washington, DC, United States Information Agency, Oct. 26,1994.**

42 Joan Bissell et al., National *Geographic Kids Network and Language Minority Students: The Use and Adaptation of the Hello! Telecommunications Unit in California Public Schools* (Irvine, **CA: Department of Education, University of California & July 1994), p. 24.**

43 Steinmetz, op. cit., footnote 23, p. 25.

Teachers' roles are often redefined in classrooms where technology has been successfully integrated. Some teachers report that they see themselves as learners alongside their students when technology is used.

Teachers at the school also said that by becoming learners themselves, they had developed greater empathy for their students. Said a teacher, "After struggling to learn [Hypercard] programming, now I'm more likely to suggest and provide alternatives instead of answers, so children can discover their own answers."[44]

At least part of the teacher's new role as "guide on the side" involves admitting to themselves and to their students that they don't have all the answers. In other words, one new role for the teacher is as a learner alongside the students. In fact, an unexpected side effect of technology use is that students, who are often more comfortable with using technology than their teachers, end up helping the teachers. One journalism teacher, initially intimidated by computers, found that her students had a totally different view of technology than she did. She described her "turnaround" this way: "Teachers tend to read the manual and say, 'This is what the computer can do.' Students tend to say, 'It's a computer, it can do anything.' This is one thing I've learned, and I learned it from my students."[45] This teacher gained a new way of thinking about the technology (it could be manipulated), the students (they could teach the teacher), and herself (she didn't know everything after all, and that was free). Could this change have occurred without technology? Perhaps. But she maintained that, as a journalism teacher, she would be remiss in her teaching if she failed to expose students to technologies now commonplace in her field. So she has let the students help her with the technology, while she teaches them the techniques and craft of journalism.[46]

In the Olympia Washington School District, students are equal partners with teachers in learning about technology applications. The director of technology described the district's approach:

> Students often introduce technological innovations into the classroom and work with teachers in developing course content and goals. The result is that often initial [technology] use by teachers does not mimic current teaching practices. We have found that using students as technical resources pays better dividends than teachers depending on colleagues. Kids take to technology faster than teachers, are more readily available, and the children's self-esteem is enhanced by being a mentor to a teacher. The Olympia School District does not give any technology workshops to teachers. Most workshops are given to students and they are taught how to pass this knowledge on to administrators, teachers, and other students. When teachers are involved in a technology workshop, they must bring a student in their class, and together they learn the skills. The pair pool their strengths, and exciting things are happening in the district's schools.[47]

[44] Ibid.

[45] Kitty Sharber, Shelbe County High School, Shelbyville, KY, OTA site visit, Apr. 18, 1994.

[46] Ibid.

[47] Dennis Harper, Director of Technology, Olympia School District, Olympia, WA, personal communication, August 1994.

ASSISTING TEACHERS WITH THE DAILY TASKS OF TEACHING

Teachers are asked to do a lot in the time they spend inside the school building—then they spend additional hours at home working on school-related projects and materials. According to data from the U.S. Department of Education, teachers spend 35 hours a week on average performing their required duties in the school building. Beyond these required school hours, teachers report spending an average of three additional hours with students—for example, coaching, tutoring, and supervising extracurricular activities—and eight more hours a week doing work activities without students, such as preparing lessons, grading assignments, and attending meetings. In 1990-91, teachers in public secondary schools were responsible for an average of five class periods a day, each with an average of 23 students. Public school teachers who were responsible for a class for a whole day, such as elementary teachers, were responsible for an average of 25 students.[48]

Technology offers alternative—and sometimes time-saving—approaches to many day-to-day functions that eat up teachers' valuable time and energy. Teachers who are comfortable using technology indicate that it can help with many important daily tasks, such as keeping records, assessing student learning, preparing and evaluating curricular materials, and increasing communication with students, colleagues, and parents.

OTA finds that teachers, like all professionals, tend to use technology when they can see how it will help them become more productive or do their jobs more professionally. Teachers use technologies in ways that are most valuable for them, whether to record grades or videotape the performance of a school play.

Evidence for how computers can support and enhance the job of the teacher emerged from a four-school pilot project in Indiana in which every teacher was given a computer and training to use it. Two years into the program, teachers reported that use of the computer had allowed them to be more efficient with the time they spent on administrative tasks, to produce work that was more professional, and to be more confident about exploring the many potential educational uses of computers (see box 2-6).

Keeping Records

As OTA observed in site visits, gradebook or other recordkeeping software can provide a "hook" that gets otherwise reluctant teachers interested in using technology tools. Most teachers spend large chunks of their time maintaining records, often detailed ones, of student scores on tests and quizzes, daily participation, homework, behavior, and other factors. Computerized gradebook programs are set up as spreadsheets; each time a new grade is entered and weighted (e.g., homework assignments, class participation, quizzes, major papers, and midterm tests), the software can automatically recalculate each student's grade averages. The teacher can print out the student's grading history and use it as a vehicle for discussing with the student or parents what that student needs to do to improve ("your quizzes were fine, but when you failed to turn in those homework assignments it really pulled your average down"). One high school math teacher, for instance, regularly uses an electronic gradebook to counsel students one-on-one about problems as they occur, and she offers to show every student his or her current grade average after each quiz or test. "When you have a quiz a week," she said, "it's too late to tell them [handing back a previous quiz] that they

[48] National Center for Education Statistics, *Schools and Staffing in the United States, A Statistical Profile, 1990-91* (Washington, DC: U.S. Department of Education, July 1993), p. 51.

BOX 2-6: What Happens When Every Teacher Gets a Computer?

As part of a pilot project funded by the state of Indiana, four small schools—three secondary schools in rural locations and one small elementary school in a suburban setting—received grants to acquire computers for the personal use of all teachers (as well as administrative staff) and to provide training for staff on the basic software provided, The project—"A Computer for Every Teacher"—was just that: all teachers in each school had to agree to participate and, in return, received a computer and printer for their own use either at home or in school (wherever they chose to keep it),

An evaluation study was conducted of the project in the spring of 1992, after the teachers had had their computers for two school years. The evaluation of this program found three areas of particular impact: teacher productivity, professionalism, and empowerment. '

Productivity Teachers and administrators reported substantial improvements in their productivity, primarily in completing administrative and management tasks. Teachers recounted spending the same amount of time on class preparation and administration, but accomplishing more, Teachers reported a side benefit: the electronic gradebook made it possible to update grades daily, This permitted teachers to provide more information to the students about their academic standing and what they had to accomplish to achieve a higher grade, improving student motivation and achievement,

Professionalism: According to the teachers and administrators who participated, the availability of computers and printers tended to improve the appearance and even the quality of materials they prepared, Class handouts, tests, flyers, and letters to parents were perceived as looking more professional and reflecting well on the school. Moreover, teachers perceived themselves as more competent because they could apply the computer to accomplish professional work, Some teachers in each school became "experts" on particular programs or aspects of software-such as mail merge—and gained the respect of colleagues, who often turned to them for help, And by being placed in the role of learner as they received training about the computer, several teachers said they were impelled to reconsider their instructional approaches, curriculum, and pedagogy.

Empowerment According to participants, learning to become proficient on the computer was a great equalizer among the faculty and between faculty and students. Teachers now felt as comfortable and proficient with computers as their students. They felt secure in suggesting computer applications to their students and willing to learn from them as well. The staff of each school reported a sense of growth and collegiality that emerged from the process of learning to use computers together, They described pride in their school for becoming leaders in the use of computers in education.

[1] Teachers and staff completed a questionnaire before the program began in 1990 In the spring of 1992, researchers made site visits to each school and conducted interviews with most of the participating staff Each teacher was given a diary form and was asked to complete a log of all uses of the computer for four randomly selected days over a two-week period in May. A followup questionnaire was also distributed to all staff; 88 percent of them completed this questionnaire A final debriefing session was held with the four school-site coordinators in late June 1992,

SOURCE: S. Rockman et al., "Productivity, Professionalism and Empowerment: Given a Computer for Every Teacher, " report prepared for the Indiana Department of Education, October 1992.

need a **96** on the next one to get an 'A.'"[49] Electronic gradebooks cart therefore become a teaching tool as well as a personal time saver, an additional benefit teachers find useful.[50]

" In schools in which the central office and teachers are linked by a local area network with access to databases of student records and management software, these programs can make it simpler for teachers to work together or with their department head or principal to analyze student work, reexamine course goals, and adjust the curriculum or instructional approach when needed. For example, at Piscataquis Community High School in Guilford, Maine, a teacher who sees that a student is having trouble in class can call up a central grade record file from the computer on his or her desk to see whether that student is doing poorly in other classes. If so, the teacher will send an e-mail message to the student's other teachers to discuss the student's difficulties and decide what actions are necessary, such as notifying the counselor and setting up a team meeting with the student's parents. Because every teacher in the school has a computer with access to the instructional management software, they use the technology as an "early warning system," allowing for intervention before student problems become too entrenched.

■ Assessing Student Learning

As noted in the 1992 OTA report, ***Testing in American Schools:***

> A quiet, but dramatic, transformation is occurring in education as researchers and practitioners rethink basic beliefs about teaching and learning. These research findings and the instructional theories they have spawned raise serious challenges to traditional classroom organizational models, to conventional curricula, and, in turn, to existing forms of testing.[51]

Some teachers are using technology to maintain and update electronic portfolios of student work. As more schools explore alternative forms of assessment, technology offers teaches new ways to quickly and efficiently record and respond to student performance.

One of the greatest challenges of alternative forms of assessment, such as performance-based assessment, is keeping track of rich but extensive histories of student performance. Some teachers are using technology to meet this challenge—maintaining electronic portfolios of student work on disk, saving hardcopies of work that students create on the computer, or requiring students to demonstrate competence and understanding through multimedia or other technology-based presentations (see box 2-7). Performance assessment methods, especially when supported by technology, help teachers diagnose student strengths and weaknesses and adapt instruction accordingly, provide students with immediate feedback on their performance, let teachers record and score multiple aspects of competence, and

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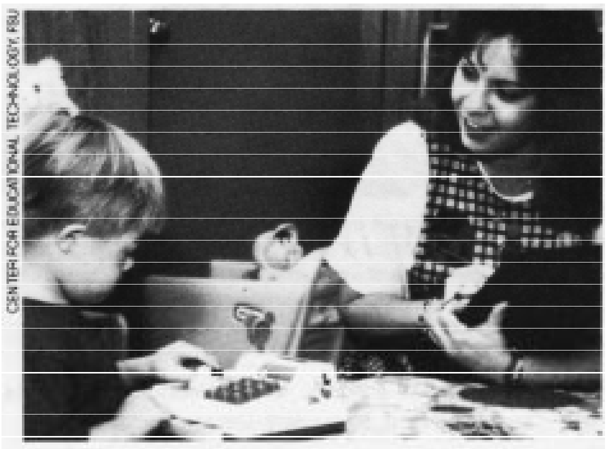
[49] Lisa Martell, Piscataquis Community High School, Guilford, ME, OTA site visit, Apr. 2,1994.

[50] See, e.g., Saul Rockman et al., Productivity, Professionalism, *and Empowerment: Given A Computer for Every Teacher,* report prepared for the Indiana Department of Education, October 1992. Also, David Stanton, "Gradebooks, the Next Generation," *Electronic Learning* (New York, NY: Scholastic, Inc., September 1994), pp. 54-58.

[51] U.S. Congress, Office of Technology Assessment, Testing in America: Asking the Right Questions, OTA-SET-519 (Washington, DC: U.S. Government Printing Office, February 1992), p. 45.

BOX 2-7: Technology Tools for Teacher Productivity

As part of a long-range, school-reform effort, the Florida School Year 2000 Initiative, Florida educators designed a specialized "teacher' productivity tool." Working with teachers across the state, the state education department, in cooperation with Florida State University's Center for Educational Technology, developed a technology tool designed to flexibly and efficiently address the grading, recording, and information retrieval aspects of teachers' jobs.



In Florida, teachers designed their own tool-the Tycho™ Teacher Inforrnation Manager--handheld, pen-based computer that helps them to create, record, and summarize student observations, report to parents, and keep track of student progress.

The tool-Tycho™ Teacher Information Manager[1]—is a combination of information management software, a pen-based hand-held computer, a central host workstation, and data communications software. Currently, 150 teachers, mostly in grades preK-2, in 20 Florida schools are using Tycho™ to create, record, and summarize student observations, report to parents, and keep track of student progress. In Leon County, Florida, the school district has purchased 1,000 units of a different platform, Apple Computer's Newton Message Pad teamed with a Wings for Learning product called "Learner Profile" in another pilot of "smart" handheld devices for student assessment,[2] Teachers using these devices can save lists of selected skills and enter corresponding assessment information for more than one student at the same time.

The convenience and flexibility of a hand-held device is obvious as teachers walk around the classroom (or wherever learning is taking place) and record information immediately. For example, a teacher can walk through a class in session with the tool in hand and record what the students are doing *as they are doing it;* later, that information can be downloaded onto the teacher's computer for more thorough re-

[1] Software was developed and marketed by American Management Systems, Inc., Fairfax, VA, Tycho software runs on a variety of Windows-based mobile computing platforms; teachers in Florida tested Tycho on a Fujitsu hand-held pen-based device,

[2] *The Heller Report,* December 1994, p. 4,

maintain an efficient, detailed, and continuous history of the student's progress.[52]

For example, some teachers use video to help make objective records of student performance and growth. A teacher can videotape a student presentation, speech, demonstration, or performance and review it later, several times if necessary, to analyze and evaluate the student's performance. The teacher and student can view the-tape together and discuss progress or areas of concern. The tape can also be stored and revisited later in the year to see how far the student has progressed or to sham the demonstration with parents.

[52] Ibid.

BOX 2-7 (cont'd.): Technology Tools for Teacher Productivity

cordkeeping and analysis of student progress. Such products[3] can also prompt teachers to pay attention to individual student learning styles by reminding them of previous observations (e.g., accessing the file for a student named "Jimmy" would show the teacher an observation she made previously that she thought was important to the student's progress, such as: "Jimmy is learning to work well in smaller groups").

Teachers who use such technology tools say that ultimately it makes their daily work easier, more efficient, or more productive so time can be better spent addressing students' needs. Even teachers who don't use these kinds of tools seem to understand the potential: a 4th-grade teacher in Indiana says the tools could help her prepare student progress reports required by the school teacher on every student every three weeks. Presently, she needs a week just to get the records together to produce the reports, If technology could help her organize all that information, the teacher says, she would have more time and energy to devote to her students when they need it most-as they *are learning.*[4]

[3] Other products are available commercially, such as the CSL Profiles in Hand, an observation and recording tool, developed by Chancery Software, Inc., Bellingham, WA, that uses Macintosh computers and the Apple Newton MessagePad. The Learner Profile, from Wings for Learning, Scotts Valley, CA, uses bar codes so the teacher can walk around the learning environment and scan in bar codes that represent learner outcomes or teacher-specified skills to measure progress and achievement

[4] Doris Zimmerman, teacher, Shelbyville, IN, personal communication, October 1994.

SOURCE: Office of Technology Assessment, based on information provided by the Center for Educational Technology, Florida State University, Tallahassee, FL, October 1994

Many schools are calling for students to maintain portfolios of student activity, throughout a year or over several years.[53] These can be extensive documents. Storage of these materials (whether drafts of work over time, collections of pictures, test scores, reports, journal entries, self-assessment, or other items) on CD-ROM makes them more convenient to maintain, access, and update, and saves scarce storage space in classrooms and school offices.

Preparing Curricular Materials

Preparing materials for daily lessons is one of the largest parts of the teacher's day. Some teachers are using new technologies to help them preview, access, create, and incorporate new materials into their lesson plans. Word-processing software, combined with printers, for example, have proved valuable tools for teachers when preparing worksheets, creating tests, and updating lesson plans. Teachers take pride in being able to use programs like spreadsheets and word processors to produce professional-looking documents. As one high school journalism teacher says, with "the right computers and software, the school newspaper actually *looks* like a newspaper, not a student publication."[54]

Often it is the school media center where videodisc players, VCRs, computers with CD-ROM capabilities, and other hardware are available, along with collections of software and programming for preview or classroom use. For instance, a teacher

[53] For example, states such as Vermont now require student portfolios as an alternative form of assessment. Likewise, some schools have followed suit, including Webster Elementary School, San Augustine, FL, and O'Farrell Community School, San Diego, CA; both require ongoing student portfolios.

[54] Sharber, op. cit., footnote 45.

Multimedia stations with any combination of a computer videodisc player, VCR, television, or CD-ROM can be used by teachers to preview and pnepare materials for classroom use. A computer connected to a videodisc player with a barcode reader, for example, simplifies customizing classroom presentations.

might go to the school media center, review the teacher's guide and table of contents in a product like the "Windows on Science" videodisc?[5] and enter the code numbers for a particular segment she is teaching (e.g., how animals adapt to their environment). She can review the segment, choose parts she wants, and use a barcode scanner to capture that sequence and play it back in the classroom. Teachers at the Open Charter School in Los Angeles, for example, use computer-controlled videodiscs for customized presentations to students. They preselect film clips or images they want to show and stop the presentation at any point for discussion. As one teacher said, "I can talk to kids and tell them about things-like the capability of sea stars to flip over—but now I can show them. I don't need to watch an entire film to get to the part I want to see. And the students can go back and watch it over and over."[56]

New telecommunication technologies enable teachers to access information from a variety of sources-universities, schools, government agencies, or any organization that has a publicly available database. From the electronic files in the database, teachers may access documents, such as written reports, lesson plans, or research papers; graphic images such as weather maps and satellite or still camera photographs; or other kinds of information. In fact, information retrieval is one of the most common purposes for which teachers use telecommunications.[57]

Teachers who use telecommunications emphasize several advantages of electronic information retrieval. They can find sources of information that are far more current than materials in standard textbooks, such as satellite photos that may be only hours old. In addition, once teachers are comfortable using the technology, searching for relevant materials electronically may be quicker or more convenient; for example, perusing a library card catalog online is usually faster than going to the library to look. Teachers can access materials that may not be available otherwise, such as those created by colleagues, or information not published in traditional ways. Also, teachers who retrieve information electronically can easily store and use the materials when and how they want, such as adapting lesson plans for their own class.

Via telecommunications networks, teachers are now being encouraged to participate as contributors to as well as users of electronic resources. For example, the Eisenhower Clearinghouse for

[55] "Windows on Science" is published by Optical Data Corp., Warren, NJ. In 1990, the videodisc series was approved by Texas for purchase with state textbook funds.

[56] Steinmetz, op. cit., footnote 23, p. 27.

[57] Honey and Henriquez, op. cit., footnote 4, p. 19.

Mathematics and Science Education[58] is creating an electronic catalog of instructional plans written by teachers in the broad areas of mathematics and science.[59] Other network service providers have created places for teachers to distribute their own instructional plans over a network. Virginia's Public Education Network (PEN) has areas—called Academical Villages, in the Jeffersonian parlance—where teachers place materials that other teachers may download and use in their classrooms. In fact, the state's most recent technology plan, designed to replace the existing Virginia's PEN system, was influenced in part by the idea of making teacher-created documents easier to post and more accessible to network users.[60]

Improving Communication

Teaching is one of the most isolated professions. **Teachers are "classroom bound" most of the day with limited access to the outside world; yet, an essential and vital part of the job of teaching is maintaining open communications with parents, other teachers, the school office, and other professionals.**

Teachers spend a great deal of their time worrying about, helping, counseling, and sharing information with students and parents, yet they are expected to do so in most cases without the aid of technology. **Telephones, perhaps the most ubiquitous and necessary technology available to other professionals, are rare in most K-12 classrooms**. Only an estimated 12 percent of teachers (one in eight) in this country have a telephone[61] in their classrooms. As one teacher pointed out, "Telephones may be the only tool we don't give teachers because we are afraid they *will* use them."[62] Some teachers stand in line to use the one phone available to them (even, in some cases, a pay phone) in the teachers' lounge or principal's office, to make arrangements for field trips, for bringing guest speakers into their classes, or for scheduling parent volunteers. Actually, a national survey suggests that the main reason teachers want telephones in their classrooms is to contact parents about immediate problems or concerns, such as student behavior, attendance, and completion of homework.[63]

There are other duties required of teachers that would be far simpler if they had easy access to telephones. For example, educators in New York undertook a review of what it takes to convene a meeting of the school personnel required by law to meet with the parents of each special education child to review the child's Individual Education Plan.[64] They found that often six people, in many cases coming from three different buildings, were required to attend these meetings. For the teacher to go to the school office or faculty lounge and stand in line to make all the phone calls necessary to set up each meeting literally took hours of play-

[58] The Eisenhower National Clearinghouse for Mathematics and Science Education is funded by the U.S. Department of Education and is located at Ohio State University.

[59] "An Invitation To Share Your Best Work," brochure prepared by the Eisenhower National Clearinghouse for Mathematics and Science Education, Columbus, OH, n.d.

[60] Glen L. Bull et al., "Anthology: Establishing an Evolutionary Path to a Peer Client-Server Internet Architecture for Virginia's Schools," paper presented at the U.S. Department of Education Secretary's Conference on Educational Technology, Washington, DC, May 8-10, 1994.

[61] NEA Communications Survey, as cited by Henry J. Becker, table 3.1: Reported Market Penetration and Estimated Simultaneous Student Accessibility for Various Electronic Technologies, "Analysis and Trends in School Use of New Information Technologies," OTA contractor report, March 1994.

[62] "Integrating Technology and Professional Development," unpublished report, Westfields Conference Center, Chantilly, VA, Apr. 27, 1994.

[63] NEA, op. cit., footnote 61.

[64] Gregory M. Benson, director, Education Program Development, Office of Educational Technology, New York State Department of Education, personal communication, Novermber 1994.

Telecommunications use by teachers has expanded in the last few years, and the number of curriculum-based telecommunications projects is increasing as more teachers and students seek opportunities to share and evaluate ideas and activities with classrooms around the globe.

ing telephone tag with busy psychologists, counselors, resource personnel, and parents. Without easy access to phones, much less voice mail or e-mail accounts where messages can be left, the task of corralling all the required players is a scheduling nightmare.

It doesn't have to be that way. In Billings, Montana, a local business partnership has enabled the district to put a phone on every teacher's desk in the Lockwood Schools.[65] The telephone system connects teachers and students to each other, to parents, and to resources outside the school. The phone lines allow for voice mail, use of modems or fax machines from the classroom, and access to parents as the need arises. Each teacher at the Lockwood Schools also has a "broadcast" mailbox to send and receive messages to groups. For instance, if a member of the school's technology committee wants to leave a message telling other members about a meeting time, the broadcast mailbox can handle it. Voice mail lets teachers leave or retrieve messages for each other and for outside callers, such as parents, calling in to check on a homework assignment.

Telecommunications use by teachers, especially fore-mail, has expanded in the last few years,[66] and with good reason: teachers with classroom access to local or external telecommunications networks can contact other educators, experts, scientists, and practitioners to discuss issues related to their teaching practice, developments in their field, and classroom experiences. Furthermore, a growing number of teacher-based networks offer teachers a chance to connect with other people in a variety of forms. Electronic mail, users groups, and listservs, by at least one estimate, account for nearly 80 percent of the general public's use of the Internet overall; teacher use seems to reflect this trend.[67]

Schools do not have to have external network connections to receive some of the benefits of increased communications via technology. Many schools are exploring the use of internal networks as vehicles for enhancing schoolwide communication. For example, when the principal of Webster Elementary School in St. Augustine, Florida, received a model school technology grant from the state, he chose to use it first to improve communication in his school by building a "teamwork infrastructure" that would connect the teachers in his building.[68] Each of the school's 53 teachers, who were scattered across three building wings and several mobile trailers, was given a computer connected to a local area network that links all the classrooms and the principal. Teachers share lesson plans and files of teaching ideas with one another and have ready access to the principal

65 OTA site visit March 1994.

66 Becker, op. cit., footnote 61.

67 Frank Odasz, teacher on the Big Sky Network Dillon, MT, in a public address, Secretary's Conference on Educational Technology, Washington DC, May 10, 1994.

68 "The Managing Principal," *Electronic Learning* (New York, NY: Scholastic, Inc., May/June 1993), pp. 26-31.

throughout the day as questions or problems arise. The principal maintains that e-mail is "the most important technology" in his school; in addition to checking it constantly throughout the day, he issues a daily e-mail bulletin to update teachers and staff on the day's activities:

> The bulletin lets teachers know exactly what's going on. When a school has morale problems, 99 percent of the time it's because of a lack of communication. The rumor mill feeds the gossip chain and before you know it, people feel left out of the information loop. The network gives me open communication with teachers.[69]

The principal at Webster Elementary has also used the technology to streamline the paperwork within the building, creating school forms (e.g., letters to parents and field trip requests) and put them on the network so that teachers can fill them out and send them back easily. Weekly newsletters to parents, a parent-school voice messaging system, and a daily video newscast (where students, not the principal, make the day's announcements) are also important parts of this principal's approach to using technology in his school to create a "team environment" centered around open communication. And the teachers seem to like it too—according to an outside evaluation, Webster was the only one of the five Florida model schools in which 100 percent of the teaching staff were participating in the technology grant.

Local area networks (LANs) are the mode of connection planned for the Edison Project School Design.[70] The current plan outlines a goal to provide every student with a computer at home to access "the Common," a LAN linking all local Edison teachers, administrators, students, and families. Each local school's LAN will be connected to a wide area network of all the Edison schools nationwide, enabling them to communicate with one another. Computers housed in each school's media center will provide Internet access so media specialists can tap into vast resources and gather information for their schools. Edison staff suggest that at the present time the Internet is too complex for individual teachers or students to navigate.[71] Edison leaders hope that the Common will become the center of a geographical community and social center for teachers and families. They foresee richer collegial relationships and joint curriculum development among teachers, and increased parental involvement, as bulletins and notices are sent home over the network so parents can discuss student work and school issues online with teachers and school staff.

FOSTERING TEACHER PROFESSIONAL GROWTH

As with any profession, teachers need opportunities to expand their knowledge, keep pace with developments in their field, try out new methods, exchange ideas with peers and experts, and refine their skills (see box 2-8). They are also required, in most districts, to take a certain number of continuing education credits for recertification or promotions. Some of this training comes through courses or one-day workshops offered by the district, generally referred to as "inservice training." Most districts require teachers to attend one or more days a year of this inservice training, usually on a limited list of topics selected by the district. While this may be an efficient delivery system for the district, it is not always the training that a teacher needs or would choose on his or her own. In fact, research suggests that professional development is more likely to be effective when it en-

[69] Ibid., p. 27.

[70] The Edison Project, a private company formed in 1991 and based in New York City, was developed by Whittle Communications, Knoxville, TN, to create public schools "where creativity, technological sophistication, high motivation, accountability, responsiveness. . . are the norm," and to do so by "spending the same amount [of money] per student as the average school district now spends."

[71] The Edison Project Technology Implementation Plan, p. 6; and Nancy Hechinger, The Edison Project, New York, NY, personal communication, Sept. 12, 1994.

BOX 2-8: Professional Development in the Lives of Teachers

Professional development is a general term, often used interchangeably with staff development or teacher training, to indicate the structured or unstructured process by which teachers already in the classroom expand their knowledge, skills, abilities, or experience to further their effectiveness. Most states and districts have a requirement that teachers must take a certain number of hours or credits of such professional development in order to maintain their teaching certificates, or for moving ahead on the salary schedule.

Yet the amount of work time during which teachers are actually paid for professional development activities is limited. Compensated professional development opportunities are usually restricted to two to four days each year; this time often includes district meetings and classroom preparation time at the beginning of the year.[1] Any additional training or learning activities usually occur after school or on weekends on a teacher's own time. Additional release time for professional development for teachers can be particularly difficult to arrange, not only because it can be costly (substitutes must be hired to take a teacher's place), but also because of logistical difficulties. Teachers must often still prepare lesson plans for substitutes; in addition, many want to minimize the amount of instructional time away from their students since they feel responsible for covering curriculum goals and keeping students and projects moving along.

Furthermore, teachers experience multiple competing demands for their limited staff development time. Many different kinds of school-based reforms are being encouraged and most will require new learning or expertise by today's practicing teachers:

> [Teachers] are faced with a staggering array of complex reforms. Teachers are told that they have to set higher standards for all students, eliminate tracking, tailor lessons to kids' individual needs (including those with various disabilities), adopt small-group and cooperative learning techniques, design interdisciplinary and multicultural curricula, work in teams with other teachers, promote "critical" and "creative" thinking instead of rote learning, attend to children's social and emotional needs, rely on "performance assessment" instead of multiple choice tests, get with the latest technology, encourage active learning in "real-life" contexts, use fewer textbooks, and become "agents of change" in their schools.[2]

The most typical ways teachers upgrade their skills are by taking credit courses on their own at local universities or attending inservice courses or activities put on by the local school or district. These inservice activities are viewed as a vehicle to enhance teaching, provide new information to teachers, or remediate for teacher deficiencies.

Frequently, inservice training entails a single workshop or course for a group of teachers, with the assumption that "one-shot training" is all teachers need to apply their newly acquired skills, content, or techniques in the classrooms. Yet research has suggested that teachers learn best, not from one-shot lectures by experts, but by seeing methods used in actual classrooms, by trying out new techniques and getting feedback on their efforts, and by observing and talking with fellow teachers.[3] As one researcher noted:

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[1] Elizabeth Arnett, "Business People and Educators Have a Lot To Learn from Each Other," *The Harvard Education Letter,* vol. XI, No 1, January/February 1995, pp. 7-8

[2] Edward Miller, "The Old Model of Staff Development Survives in a World Where Everything Else Has Changed," *The Harvard Education Letter,* vol. XI, No. 1, January/ February 1995, p. 2.

[3] See, e.g., J. Little, "Teachers' Professional Development in a Climate of Educational Reform," *Educational Evaluation and Policy Analysis,* vol. 15, No. 2, summer 1993, pp. 129-151.

BOX 2-8 (cont'd.): Professional Development in the Lives of Teachers

> The problem of harnessing staff development is compounded by its increasingly sprawling prominence On the one hand, it is correctly seen as the central strategy for Improvement. On the other hand, it is frequently separated artificially from the institutional and personal contexts in which it operates.[4]

Professional development efforts have evolved over the years in several directions. Two very different approaches to professional development have been in competition with each other for the past 40 years—professional development as a form of remediation versus professional development as a method of culture building within a school:

> One approach--deficit training-views teaching as technical work and seeks to improve it by training teachers in a set of techniques and discrete behavior. This approach has, in fact, been dominant The other approach---growth and practice-defines teachers as professionals, views them as having requisite knowledge to act on behalf of their students, and seeks to develop structures to enable them to collaborate with colleagues and participate in their own renewal and the renewal of their schools.[5]

Recent research suggests that professional development may work best when schools create working conditions for teachers that foster continuous learning and professional growth, such as providing opportunities for teachers to reflect on their teaching practice or to refine ideas with colleagues, For example, in the Tupelo (Mississippi) School District, teachers are encouraged to travel to other school districts to gain a new idea about how to improve practices in their own classrooms If a teacher convinces the Tupelo district to try the practices that he or she has observed, the district will pay for the cost of changes in that teacher's classroom.[6] The superintendent of schools in Tupelo says

> You can't tell people how to do things; they have to experience it, and it has to make sense to them. So we provide [money] for any teacher in the district to go anywhere in America. to observe cutting edge educational practices We don't require that they return to the district and change anything, but what's happening is that they are seeing other, new ways of teaching.[7]

Yet the biggest barrier to professional development of teachers is simply lack of time in the school day or calendar. According to *Prisoners of Time,* the widely quoted report of the National Education Commission on Time and Learning:

> The greatest resistance of all [to reallocating time in schools] is found m the conviction that the only valid use of teachers' time is "in front of the class;" the assumption is that reading, planning, collaboration with other teachers, and professional development are somehow a waste of time.[8]

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[4] Michael G. Fullan, "Staff Development, Innovation, and Institutional Development, " in Bruce Joyce (ed.), *Changing School Culture Through Staff Development,* 1990 Yearbook of the Association for Supervision and Curriculum Development, p 4

[5] Ann Lieberman and Lynne Miller, "Professional Development of Teachers, " *Encyclopedia of Educational Research,* 6th Ed., vol. 3, M. Alkin (ed.) (New York, NY Macmillan Publishers, 1992), p 1049

[6] As of early 1992, several "grants" had been awarded to teachers so they could change practices in their classrooms Funding has been provided through a $3.5-million private endowment to the district. Isabelle Bruder, "Underwriting Change, "*Electronic Learning (New* York, NY, Scholastic, Inc., February 1992), pp. 26-27.

[7] Ibid

[8] The National Commission on Time and Learning is a nine-member independent advisory board established by the Education Council Act of 1991 and charged with conducting a comprehensive, two-year review of the relationship between time and learning in the American schools. *Prisoners of Time* (Washington, DC: U.S. Government Printing Office, April 1994), p 17

(continued)

BOX 2-8 (cont'd.): Professional Development in the Lives of Teachers

One of eight recommendations set forth in the Commission's report is to give teachers time to learn or prepare better for their work Evidence suggests that teachers are committed to improving their own knowledge and practice even on their own time. One study of the costs of staff development found that for every dollar spent by districts and schools directly on formal staff development activities, individual teachers personally contributed 60 cents in their own time, with no present or future financial compensation.[9]

Some schools and teachers are finding that technology can be a great resource to facilitate new kinds of professional development, some technologies may help solve time and distance problems that have traditionally interfered with collegial interaction. For example, electronic mail can circumvent the problem of teachers not being free for collaboration or discussion at the same time as their colleagues. Telecommunications technology can also pull together biology teachers scattered across a large geographical area or enable teachers to take online credit courses from home. Videotaping technologies allow teachers to record their own teaching, for supervision and observation purposes; it also allows the work of "master teachers" to be recorded and shared with others. Telecommunications technologies are fostering the growth of "electronic communities" of teachers who can share teaching experiences, problems, lesson plans, and new ideas.

[9]Judith Warren Little et al., *Staff Development in California* (San Francisco, CA Far West Laboratory for Educational Research and Development, December 1987)

SOURCE Office of Technology Assessment, 1995

courages teachers to participate in their own renewal rather than supplying teachers with prepackaged information or training.[72] Yet many teachers are far from colleges, universities, or central training resources in a state or district that might offer courses or topics of interest in their teaching field. Technology is one means of filling this gap. **Increasingly, technology can provide teachers access to new ideas, master teachers and other professionals outside the school setting, and courses and enrichment activities both formal and informal. It can also make it possible to provide continuing support after courses end or after educators have "met" over a network.**

■ Expanding Opportunities for Formal Continuing Education

Technology-based resources can greatly enhance opportunities for convenient, flexible, continuing education courses and workshops—whether required for recertification or taken for personal growth.[73] Educational programs and courses offered over cable or public television, distance-learning networks, packaged video (videotape, videodisc, or CD-ROM), and telecommunications networks can extend the range of options for a teacher's study (see box 2-9).

Distance-learning technologies enable learners in locations distant from one another and/or the

[72] Ann Lieberman and Lynne Miller, "Professional Development of Teachers," *Encyclopedia of Educational Research,* 6th Ed., M. Alkin (cd.) (New York, NY: MacMillan Publishers, 1992), vol. 3, pp. 1045-1053.

73 U.S. Congress, Office of Technology Assessment, *Linking for Learning: A New Course for Education,* OTA-SET-430 (Washington, DC: U.S. Government Printing Office, 1989).

instructor to participate in courses via video, audio, and computer technologies. These technologies are increasingly being used to provide instruction not just for students, but also for teachers and other school staff. For example, teachers in the 90 school districts in Los Angeles County participate in staff development programs offered by the LA County Office of Education's satellite-based Educational Telecommunications Network (ETN).[74] This service was developed in response to the need to provide equitable staff development for teachers regardless of local budget and geographic constraints. A range of courses are offered on topics such as "Making Economics Come Alive in the High School Classroom," "Grouping for Instruction in Language Arts, K-12," or "Creating an Emotionally Safe School: Conflict Resolution and Peer Mediation." The programs and courses are led by experts—many of whom are local teachers—from the ETN studios and sent by satellite signal to school sites around the county that have satellite dishes to receive the broadcast signal. Participants can call in and interact by telephone with the presenters in the studio. Each participating school site also has a facilitator who leads discussions and other activities after the broadcast.

Teachers looking for ways to improve their own teaching may also engage in what researchers refer to as "reflective practice." Technology can provide valuable resources for extending this concept. Reflective practice involves asking focused questions, sharing concerns, seeking common meanings in teaching practice, or constructing ideas in collaboration with other teachers. "Video has a long, successful tradition as a means to support this form of collaborative learning among teachers. Moreover, research supports the notion that shared observation, discussion, and planning of teaching in peer groups can lead to improved practice."[75] Typically, to learn from other teachers, a teacher has to find time to watch and observe in classrooms—a difficult scheduling feat for most teachers. Video allows classroom interactions or master teachers to be taped for convenient viewing. Or teachers can tape themselves teaching, then ask a colleague, principal, or coach to offer a critique or perspective.

One group of researchers has been organizing teachers into video "clubs" on a school or district basis. Teachers make videotapes of their own teaching and teacher-student interactions. The clubs watch and discuss one another's videos as well as videos of exemplary practice. The groups have a facilitator who helps them focus on relating standards of exemplary teaching to their own practice.[76] This can be particularly valuable for student teachers or new teachers just learning their craft, but it is also being used as a part of the process for preparing teachers to meet the standards for Master Teachers set forth by the National Board for Professional Teaching Standards (see chapter 5).

Telecommunications-based electronic communities are another vehicle for teachers to engage in reflective practice.[77] An electronic community can be a nonjudgmental forum for

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[74] Information about ETN provided by Sandra Lapham, consultant-in-charge, Instructional Media and Technologies, Los Angeles County Office of Education, August 1994, *ETN Program Guide, 1993-94,* Los Angeles County Office of Education.

[75] Jeremey Rochelle, Cherie Del Carlo, and John Frederiksen, "Restructuring Through Video-Based Reflection on Practice," unpublished manuscript, Institute for Research on Learning and Educational Testing Service, n.d., p. 2.

[76] Ibid.

[77] See, for example, the AT&T Learning Circles project and the TERC LabNet project, started in 1989. LabNet provides support for high school science teachers; the project is designed as a community of practice, connected mainly by a telecommunications network through America Online. There are currently more than 500 teachers in the project, experimenting with new teaching strategies, reflecting on teaching experiences, sharing resources, solving problems, and building collegial relationships. William Spitzer et al., *Fostering Reflective Dialogues for Teacher Professional Development* (Cambridge, MA: TERC, 1994).

BOX 2-9: Mathline: A New Approach to Professional Development for Mathematics Teachers

When the National Council of Teachers of Mathematics (NCTM) issued standards for teaching mathematics, educators around the country applauded this first set of educational standards promoted by a national professional association. However, agreeing on the standards—and developing the suggested content, materials, tools and approaches to teaching in support of these standards—was a substantial challenge. Even more daunting is the challenge of getting the word out to educators and helping them implement this new vision of mathematics education in schools around the nation. To respond to this need, the Public Broadcasting System (PBS) created a new framework for professional teacher education, channeling the resources of its *347* affiliated public television stations nationwide and their experience in working with local educators.

The opportunity for PBS to enhance traditional educational services to schools came in 1993 with the launching of Telstar 401, a state-of-the-art satellite greatly expanding programming capacity. This expanded satellite access, combined with VSATs (very small aperture terminals), telephone, television, and computer technologies made it possible for PBS to also offer interactive data, voice, video, and multimedia educational services to teachers and students. "We've tried to bring together technologies in a way that really services people, " said PBS's executive vice president for education[1] " ... we started (with math) because it was the NCTM that was first out of the box with standards" for curriculum, In collaboration with NCTM,[2] in the fall of 1994, PBS launched Mathline, the first discipline-based educational service offered over the PBS "telecommunications highway. "

The Middle School Math Project, the first of several planned Mathline services, is a year-long professional development course for middle school mathematics teachers. Each Mathline group has approximately 25 teachers—some self-selected, some chosen by their schools—and a mentor teacher. The management of each project is handled locally by the 20 participating public broadcasting stations, representing 16 states. The local stations do more than broadcast video lessons—they also distribute course materials over the computer network and offer technical and organizational support to participants.

With the assistance of NCTM math consultants, the PBS affiliate Thirteen/WNET in New York produced a series of 25 hour-long video segments, in which teachers demonstrate and model the instructional approach and content promoted by math standards (e.g., ways to help build students' skills in reasoning, estimating, communicating, and problem-solving in math). In the "Something Fishy" video, for example, a Maryland teacher uses small fish-shaped crackers to demonstrate how students can learn how proportions can be used to count a large population (e.g., the number of fish in the entire Chesapeake Bay).[3] The videos are aired on the local PBS station at a time when teachers can tape them (at home or school) for viewing later at their own convenience, or several times to study key points in detail as they choose. The groups discuss the videos in an online discussion facilitated by a master teacher. In a discussion of the "Something Fishy" lesson, for example, one teacher commented that, although the concept was a good one, the technique would never work in most classrooms: "The kids would eat the crackers before the lesson was over!"4

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[1] Sandra Welch, quoted in Mark Walsh, "Station Break, " *Education Week,* Oct. 12, 1994, p. 24.

[2] Funding support was also supplied by the Corporation for Public Broadcasting, the AT&T Foundation, the Carnegie Corporation of New York, and the Cellular Telecommunications Industry Association

[3] Walsh, op. cit., footnote 1, p. 25.

[4] Jinny Goldstein, vice president, Education Project Development, PBS, Alexandria, VA, personal communication, January 1995.

BOX 2-9 (cont'd.): Mathline: A New Approach to Professional Development for Mathematics Teachers

In addition to the video segments and discussions, two national video conferences are broadcast live, presenting the opportunity for teachers to talk with math educators and expert teachers from around the country. The participating teachers can call in their reactions and questions live, tape the videoconferences for later review, and discuss the ideas and questions generated in their subsequent computer conferences.

The model is new for professional development—interactive, flexible, reaching teachers in local communities who might not otherwise have access to high quality professional development. The teachers' reactions, halfway through the initial year, have been positive. As a teacher in Spring Lake Park, Minnesota, said, "Most teachers are isolated in their classrooms. This gives them exposure."[5] The facilitator for her project suggests that teachers respond well to being freed from inflexible inservice training at a set time and place. "They can sit in 10 minutes here or there to participate in the discussion. You also tend to get a lot more thoughtful responses than you might get in a teaching seminar."[6] Despite the fact that they may never meet face to face, the class becomes an electronic community of learners.

Under a grant from the Rockefeller Foundation, PBS is studying the feasibility of using the Middle School Math Project as a model for other professional development activities for teachers, across a range of content areas. The lessons learned in the pilot project for middle school math teachers will form a basis for considering future steps.

[5] Walsh, op. cit., footnote 1, p. 25.

[6] Ibid.

SOURCES: Office of Technology Assessment, 1995; based on Public Broadcasting Service materials and personal communications, January 1995

teachers to ask questions, solicit opinions, and explore personal philosophies with the aim of improving their teaching.[78] Through these kinds of exchanges, teachers can also build collegial relationships and become more adept at learning from each other.

Fostering Collegial Work with Other Professionals

American schools tend to be structured in ways that do not encourage collegial work among teachers. Unlike schools in some other countries, time is not set aside in the teacher's day for working with colleagues on a regular basis.[79]

> Teaching, more than many other occupations, is practiced in isolation, an isolation that is at times crushing in its separateness. Collegiality is non-existent for many teachers, unless hurried lunches over plastic trays in unkempt lunchrooms are viewed as exercises in colleagueship, rather than the complaint sessions they are more likely to be. Knowledge is the currency in which a teacher deals, and yet the teach-

[78] Spitzer, ibid., pp. 7-8.

[79] In Japan, for example, teachers typically have more students per class (35 to 40 versus 23 in the United States), but Japanese teachers are only in front of the class four hours a day. Likewise, teachers in Germany are in class with students 21 to 24 hours per week, but their work week is 38 hours. In these countries, time outside the classroom is considered essential to the teachers' professional development. National Education Commission on Time and Learning, *Prisoners of Time* (Washington, DC: U.S. Government Printing Office, April 1994), pp. 23-27.

> er's own knowledge is allowed to become stale and devalued, as though ideas were not the lifeblood of the occupation. The organizational structure of schools, so far as the professional staff is concerned, is built on a series of one-on-one relationships. Since there is little incentive for teachers to integrate their behavior with that of other teachers, they tend to go their own ways. Teachers are so accustomed to working on their own that they are surprised when someone tries to act as a colleague and collaborate.[80]

As discussed in chapter 4, most teachers' days allow them little time or specific opportunities to share ideas and communicate with colleagues, and there is little incentive for them to work together. Some teachers who have had regular opportunities to interact with other teachers—in person or electronically—report that the collegial support they receive far exceeds their expectations. One teacher in Florida who team-teaches once a week said, "I could never go back to teaching alone. I can't imagine how I did it before."[81] This teacher received time and support from her school to plan and prepare lessons with other teachers; she felt that the chance to draw on another teacher's expertise and contribute her own knowledge was invaluable. As one education writer pointed out, "The beginning of the end of isolation is bringing teachers together. Teachers feel more powerful when they are part of a group with a common purpose than when they labor on their own."[82]

Some teachers have found online resources, such as listservs, bulletin boards, or e-mail, to be a convenient and time-saving way to connect with colleagues and other professionals or resources outside the school. Some networks, such as TENET in Texas, Virginia's PEN, and the Scholastic Network, are designed specifically for teacher inquiry and growth. Teachers also use commercial networks like America Online and Prodigy for this purpose; many of these networks have educational forums. Teachers who use these services say that the exposure to new colleagues, ideas, and resources can invigorate their enthusiasm for their own learning (see box 2-10). As a recent survey of accomplished educators' use of telecommunications found:

> . . . the opportunity to communicate with other educators and share ideas [is] one of the major benefits of this technology. Obtaining rapid feedback on curricular issues and other topics of professional interest, and keeping current on subject matter, pedagogy, and technology trends are also important incentives.[83]

A teacher in Kentucky who subscribes to the service Prodigy[84] and regularly uses it at home, noted that she has forged an online relationship with people in her state department of education. "I didn't even know who they were when I first got online," she said, "but we had some of the same questions we wanted answered, and they didn't all have to do with my school. I still haven't met them face-to-face, but I feel like I know them."[85]

Some learning opportunities allow teachers to contribute to the resource base of expertise, not just take from it. For example, the Bellevue Washington School District network—called Belnet—has been used to further the district's philosophy of peers learning from peers. Teachers use the network for planning and joint teaching efforts. New ideas about instructional practice, materials, and strategies pass through the network, as do discussions about using technology to promote learning.

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[80] Gene I. Maeroff, *The Empowerment of Teachers: Overcoming the Crisis of Confidence* (New York, NY: Teachers College Press, 1988), p. 3.

[81] Nancy McLaughlin, Webster Elementary School, St. Augustine, FL, OTA site visit, Apr. 20, 1994.

[82] Maeroff, op. cit., footnote 80, p. 24.

[83] Honey and Henríquez, op. cit., footnote 4, p. 19.

[84] Prodigy—like America Online and others—is a commercial telecommunications networking system that charges a monthly fee (approximately $9.95) and hourly rates ($2.95/hour) for use of the network. Costs include software for connectivity.

[85] Debbie Hall, Shelbyville, KY, OTA site visit, Apr. 18, 1994.

BOX 2-10: Teacher Collegial Exchange Using Telecommunications

Perhaps one of the greatest benefits for teachers using telecommunications technologies is the ability to engage in collegial exchanges—the opportunity to talk with other teachers about teaching. For example, a teacher in Alaska can communicate with a teacher in South Carolina to discuss the ways in which both are using *The Diary of Anne Frank* in their respective literature classes; these teachers can share lesson plans, collaborate on activities online, discuss students' difficulties or successes, and generally offer support to each other as the school year progresses.

Below are some examples of teacher dialogs in which teachers discuss some of the ways they use telecommunications in their teaching and in their professional life. These teacher comments came from BreadNet, the telecommunications network established by the Bread Loaf School of English at Middlebury College in Vermont, for secondary school English teachers. The enthusiasm and sense of collegial support is common among telecommunications users worldwide

> I must assure you that the network has changed my classroom. This year we have opened up our room to the rest of the nation, We are isolated here, especially in the cultural sense. My class has become aware of the differences and similarities of students in Hawaii, Vermont, Mississippi, South Carolina, as well as bush and urban Alaska. Discussions in class often center around how differently or similarly students we are communicating with view a certain idea. When we went on a recent trip to see the Anne Frank exhibit in Anchorage, students commented they wished everyone we had been writing to [throughout the year] could have been with us My students will never again view Native Alaskan culture in the narrow fashion theyh ad viewed it before this year, Just that one concept change is worth the whole project.—Teacher, *Trapper Creek, Alaska.*

> Let me share with you a very real success story. Kelly, a very bright 11th grader in Honors English, was painfully shy, She would take a "O" before she would stand before her classmates and speak. However, as soon as she began to "talk" online, I saw her begin to shine She expressed her views on our [class] poems in a clever, insightful, and witty manner. I took her to the conference in Myrtle Beach and while she would still not speak before the educators at our inservice, there has been a great deal of change in her at our school. She has gained confidence from positive feedback online and is now preparing to do a special oral presentation on Wordsworth for her classmates. I honestly feel that the telecommumcations experience allowed her to view herself on another and more positive light.— *Teacher, Pawleys Island, South Carolina.*

> My children were able to participate in two projects on Bread Net. One was responding to the Korean Tale "Story Spirits," which went into a publication with responses from Alaska and Virginia. They were very proud and excited to see their responses printed alongside those of middle and high school students! The parents were also impressed. The children also contributed to a statewide newsletter about what was happening in our schools.

> One of the most exciting things I participated in was the Alaska publication of "A Day in the Life of a Teacher." It made me rethink my philosophy and set down honest thoughts The thoughts of my colleagues astounded me and gave me new directions in my own thinking. The establishment of the Alaska Teacher-Researcher Network folder [online] gave us an easy avenue for communication that we have had difficulty establishing on the university system. This is due to the ease of the software. I have been able to connect to colleagues around the nation on a beginning project about the inclusion of special education students in the regular middle and high school classroom

> While BreadNet has not become a regular fixture in my classroom [for instructional purposes] for a number of reasons, it has become a definite fixture m my professional life Being able to communicate with colleagues in my state and nation on such an expedient basis has opened new avenues for me in my professional life. *—Teacher, Juneau, Alaska*

SOURCE: Office of Technology Assessment, based on teacher comments contained in unpublished documents obtained from Jim Maddox, Director, Breadloaf School of English, compiled for PBS Retreat, Apr. 27, 1994.

APPLE COMPUTER, INC.

Teachers use technology for many reasons, but ultimately getting and keeping students engaged in learning is the strongest motivation.

The system, which is connected to the Internet, also provides a followup to staff development; when teachers complete a class, they can gain additional help, or advice from their peers on Belnet.[86]

Sometimes collegial support is an added benefit of a student-centered project, as shown by the Georgia ClassConnect project, a trial project that connects four high schools and four colleges. Teachers at any of the eight sites have a chance to teach a group of students at any or all of the other seven sites. Classrooms are equipped with technologies to facilitate full interaction: monitors, cameras, instructor and ceiling-suspended microphones, a fax machine, a document camera, and a personal computer that controls the equipment at each location. Although the primary focus of this pilot project is distance learning for the students, teachers have learned methods and strategies watching their colleagues that they have incorporated into their own teaching.[87]

CONCLUSION

The central question for a teacher has always been: how can this help my students? This is as it should be, and will not change as technology enters the classroom. However, although research on educational technology has consistently focused on how it mayor may not benefit students, students are not on their own in schools. It maybe time to rewrite the question and direct more research efforts to explore some answers for teachers. **Helping teachers may, in fact, be the most important step to helping students.**

The examples in this chapter illustrate several ways in which technology can help teachers improve instruction, change the teaching and learning process, fulfill daily tasks, and engage in regular professional development. But these visions of what is possible are far from the reality in many schools and for the typical teacher. As the next chapter will show, many schools do not have the basic technology infrastructure to support telecommunications and other newer applications. And as chapter 4 will explain, there are scheduling, organizational, curriculum, and other barriers in many schools that hamper more effective use of technology by teachers. Furthermore, as chapter 5 explains, if new teachers are not well prepared to use technology as they enter the classroom, they start teaching at a disadvantage. Chapter 6 suggests federal programs are attempting to improve the nation's capacity to help teachers learn about technology.

Still, as this chapter and others indicate, teachers in a wide range of settings are overcoming the barriers, blazing new trails, and learning lessons from which others can benefit. Clearly, technology implementation is a challenging task. Teachers need support if it is to become a reality.

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[86] John R. Mergendoller et al., "Exemplary Approaches to Training Teachers to Use Technology," OTA contractor report, September 1994.

[87] William R. Jordan, "Using Technology to Improve Teaching and Learning," *Dynamite Ideas: Georgia ClassConnect* (Greensboro, NC: SERVE, 1993), p. 23.

Technology Access and Instructional Use in Schools Today 3

SUMMARY OF KEY FINDINGS

- Research to date has collected only minimal data from teachers about how much technology is available to them and how they use various technologies for instructional or professional use.
- Projections suggest that by spring 1995, U.S. schools will have 5.8 million computers in use for instruction—about one for every nine students. Nevertheless, a substantial number of teachers still report little or no use of computers for instruction.
- Compared with other countries, the United States leads the world in the sheer number of instructional computers in schools. About half the computers in U.S. schools, however, are older, 8-bit machines that cannot support CD-ROM-sized databases or network integrated systems or run complex software. This problem is particularly pronounced in elementary schools. When compared on the availability of the more powerful 16- or 32-bit computers, the United States falls well below other countries. This aging inventory limits the ability of many teachers to use some of the most exciting applications of computers.
- During the past two years, the most rapid growth of technology in schools has been in CD-ROMs, videodiscs, modems, and local area networks (LANs). Available data are weakest in providing information about how much access schools actually have to these newer technologies, much less how they are being used.
- Video is the most common technology used for instruction in schools; sources include direct broadcast, cable, satellite, or videotaped programming. As of 1991, the typical school had seven TVs and six videocassette recorders (VCRs). Most

teachers make some use of video instruction during the school year, but data about kinds of use and effectiveness are lacking.

- The most common uses of technology in schools today are the use of video for presenting information, the use of computers for basic skills practice at the elementary and middle-school levels, and the use of word-processing and other generic programs for developing computer-specific skills in middle and high schools. Other uses of technologies—such as desktop publishing, developing mathematical or scientific reasoning with computer simulations, information gathering from databases on CD-ROM or networks, or communicating by electronic mail—are much rarer in the classroom. Technologies are not used widely in traditional academic subjects in secondary schools.
- Schools do not always locate their technology in the most accessible sites. Most schools still place a majority of their computers in computer labs rather than individual teacher's classrooms. Similarly, modems may be located on a central computer in the principal's office, making it difficult for teachers to integrate computer or telecommunications activities with other learning or professional activities during the course of a day.
- High schools are more likely than elementary schools to have newer or more powerful computers, LANs, hard disk drives, laser printers, videodisc players, and distance-learning capabilities. The greatest disparities in the distribution of computers among schools at the same level (i.e., elementary, middle, secondary) are found between small schools and large schools. Schools with fewer students tend to have many more computers per student. This pattern of more resources per student in smaller schools also holds for video equipment such as VCRs and TVs.
- The majority of K-12 schools are ill-equipped to participate in the opportunities presented by telecommunications networks. While telephones, modems, fax machines, and other telecommunications links with the outside world are present to varying degrees in school buildings, they are not yet generally found in classrooms. Fewer than one teacher in eight has a telephone in the classroom. Furthermore, most schools lack connectivity, administrative and organizational support, and technical expertise to integrate electronic networks into the teaching and learning process. Major investments of time and other resources will be required to prepare schools to effectively use electronic communities.

INTRODUCTION

As demonstrated by many promising examples throughout the United States (see chapter 2), technology can be a rich resource for teachers of all kinds to use in various educational settings. With available technologies, teachers can solve a range of educational problems, meet a variety of learning goals in all curriculum areas, and serve varying age levels or student populations. In addition, technologies offer teachers tools for accomplishing a variety of administrative tasks and for enhancing their own professional development.

Before teachers and students can use technology for these ends, however, they must have access to the hardware and software. How widespread is access to various technologies in classrooms today? How much and what kinds of technologies are available to the typical teacher? How are available technologies being used? This chapter attempts to provide an objective statistical portrait of the presence and use of educational technologies in American schools. The technologies covered include:

- computers of different levels of power and sophistication;
- computer-based equipment such as CD-ROMs, printers, and LANs;
- video resources such as televisions, videocassette recorders, cable, satellite, and videodisc players; and
- telecommunications networks and other technologies for two-way communication of voice, data, and graphics.

Statistical information in this chapter comes principally from three major nationwide surveys of schools, teachers, and students conducted in the United States between 1989 and 1993[1]: the U.S. portion of the 1992 Computers in Education Study of the International Association for the Evaluation of Educational Achievement (IEA),[2] the 1991 National Study of School Uses of Television and Video conducted by the Corporation for Public Broadcasting (CPB),[3] and the 1993 Communications Survey of Member Teachers of the National Education Association (NEA).[4]

Although these are the best, most nationally representative data sources[5] currently available, they still provide only a rough estimate of what schools are doing with technology. In part, this is because the landscape is changing so rapidly—hardware and software available in today's marketplace have grown in technical sophistication and decreased in cost compared with what was available just a few years ago. In addition, much of the available survey data come from principals or technology coordinators who tend to focus more on technology access and use at the building or district level rather than the classroom level. **In general, recent national survey data are weakest in providing information about the classroom context of technology use and teachers' professional use of computers**.

Available data are also lacking regarding access and use of telecommunications networks by teachers and schools—in part, because these applications have been increasing so rapidly in the past several years. Telecommunications networks allow teachers to interact with other professionals and take advantage of resources beyond the limits of their school or community. This chapter will discuss the ways in which schools are obtaining access to these networks and factors that affect their participation.

WHAT TECHNOLOGIES DO SCHOOLS OWN AND HOW ARE THEY USED?

Available survey data provide a picture of which technologies schools own and how much the average school has. In examining these data, however, one must remember that the presence of hardware is only a first step. To use hardware effectively, schools also must acquire the computer software and video programming that give it life and must orchestrate the available equipment to make it accessible to teachers and students. Teachers need to see the value of using technology, have an idea of how to use technologies effectively to accomplish their instructional goals, and must receive the training and continuing support necessary to overcome the inevitable challenges technology poses.

Estimating the amount of hardware available in schools today is relatively easy compared with estimating how frequently it is used and for what purposes. Yet information about the uses of technology is necessary for under-

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[1] Much of this chapter is adapted from Henry J. Becker, "Analysis and Trends of School Use of New Information Technologies," contractor report prepared for the Office of Technology Assessment, March 1994. In this contractor report, results of a number of major national surveys of educational technology were synthesized and analyzed. See appendix B.

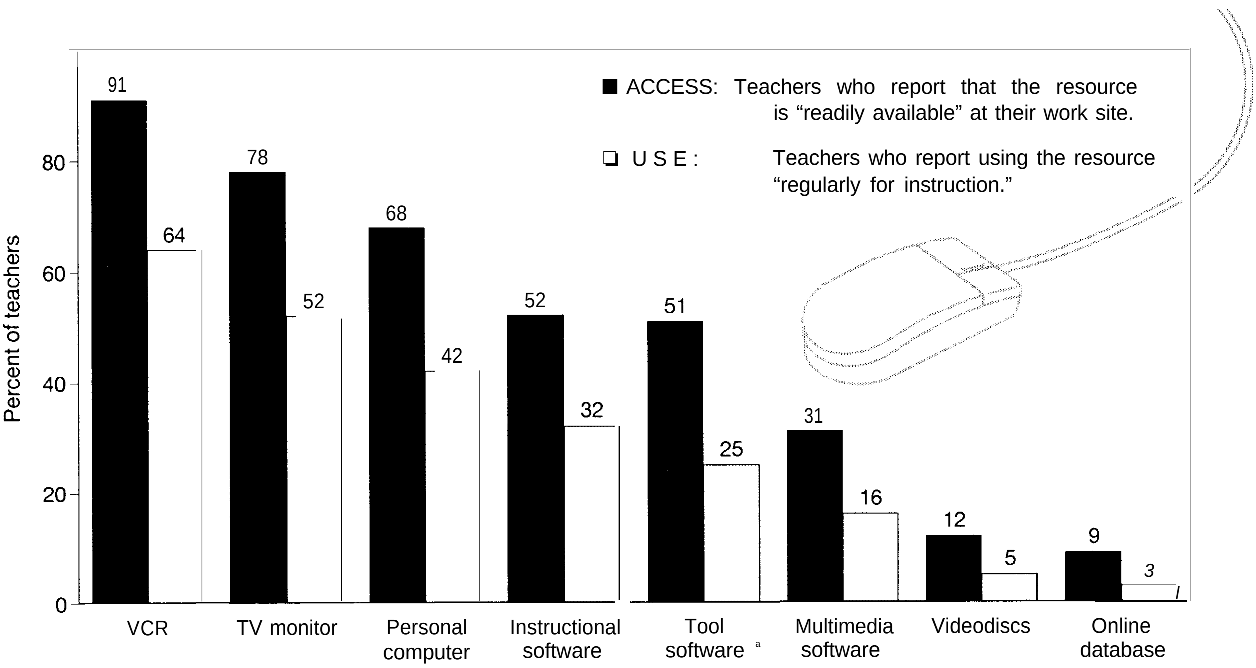
[2] Ronald E. Anderson et al., *Computers in American Schools, 1992: An Overview,* International Association for the Evaluation of Educational Achievement Computers in Education Study (Minneapolis, MN: University of Minnesota, 1993).

[3] Andrew L. Russell and Thomas R. Curtin, *Study of School Uses of Television and Video: 1990-1991 School Year* (Arlington, VA: Corporation for Public Broadcasting, February 1993). Also, see Research Triangle Institute, *Study of the School Uses of Television and Video: Methodology Report* (Research Triangle Park, NC: Research Triangle Institute, Mar. 20, 1992).

[4] Princeton Survey Research, *National Education Association Communications Survey: Report of the Findings* (Princeton, NJ: Princeton Survey Research Associates, June 2, 1993).

[5] This chapter also includes information from reports in progress or published and technical documents related to these three studies. The major features of these three studies and the four other studies used in the analysis are described in appendix B.

FIGURE 3-1: Teacher Reports of Access and Use of Technology Resources, 1991



[a] For example, word processing, database management, spreadsheet

SOURCE: National Education Association, *Status of the American Public School Teacher, 1990-1991* (Washington, DC: 1992)

standing the status of technology in today's schools.

One nationally representative survey of teachers illustrates the gap that often occurs between having access to technology and actually using it.[6] Teachers who reported having various technology resources "readily available" at their worksite were asked if they used that resource "regularly." About 70 percent of teachers who have access to video resources use them regularly, and about 60 percent with access to personal computers use them regularly (see figure 3-l). Among teachers who have access to multimedia, videodiscs, online databases, and other newer technologies, an even smaller share report using them regularly.

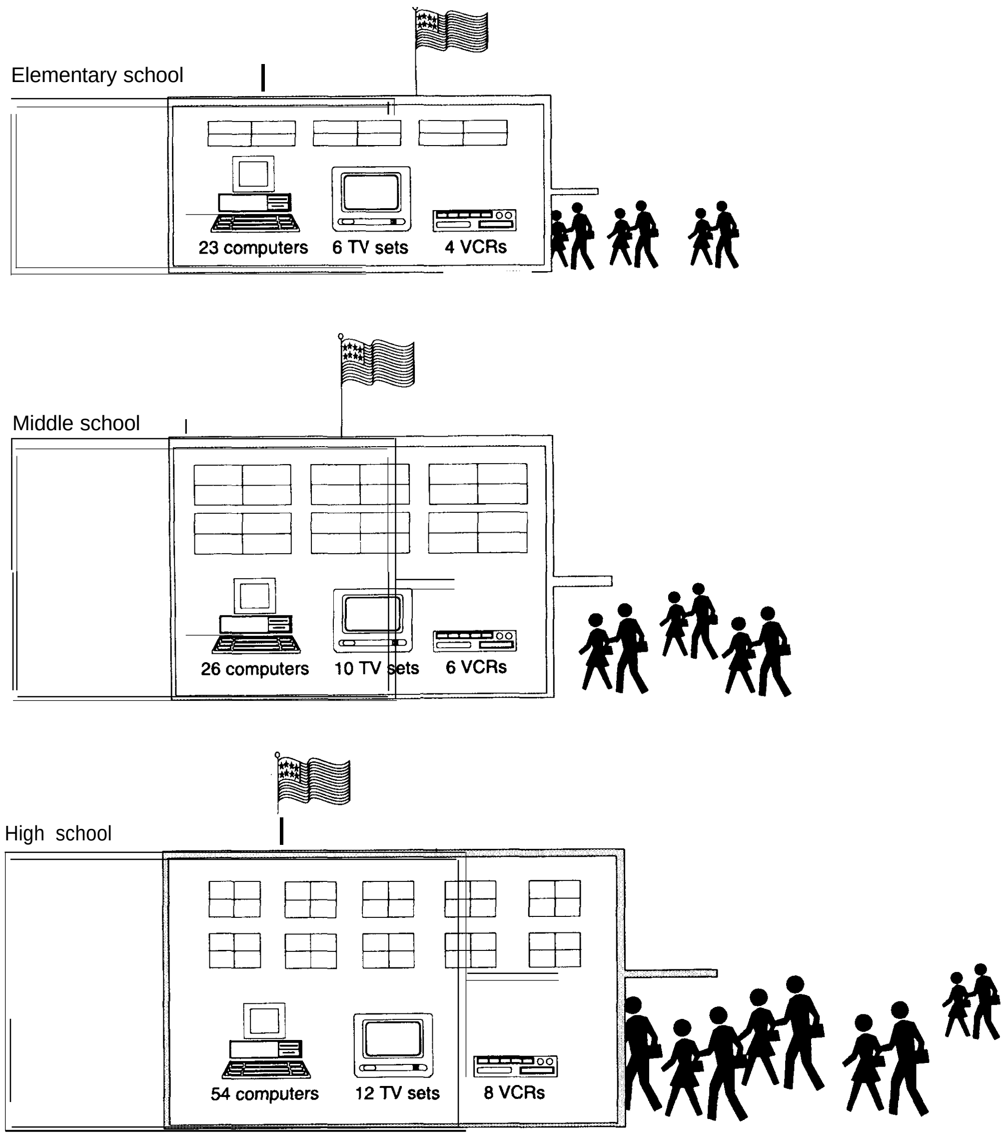
Computers

Of their total expenditures to date for technology (as defined in this report), schools have spent the most on computers. Over the past decade, schools have spent roughly $500 million on new computers. Between 1989 and 1992, for example, schools added 1.1 million computers, increasing their inventory by nearly 50 percent, from 2.4 million to 3.5 million.

The typical high school in 1992 had 54 computers (median), and the typical elementary or middle school had about 25 (see figure 3-2). The United States leads the world in sheer numbers of computers in schools (see box 3-l), although many of

[6] National Education Association, *Status of the American Public School Teacher 1990-91* (Washington, DC: National Education Association, 1992).

FIGURE 3-2: Installed Base of Computer and Video Technologies in Typical Schools, 1991-92



NOTE: Figures given are medians. Computer data from 1992, video from 1991.

SOURCES: R.E. Anderson (ed.), *Computers in American Schools* 7992: *An Overview* (Minneapolis, MN: University of Minnesota, 1993). A.L. Russell and T.R. Curtin (eds.), *Study of School Uses of Televisions and Video: 1990-97 School Year* (Arlington, VA: Corporation for Public Broadcasting, 1993).

BOX 3-1: Results from an International Study of Computers in Education

In 1989, the International Association for the Evaluation of Educational Achievement (IEA) conducted its first Computers in Education study of schools in 23 countries, including Austria, Germany, Japan, the Netherlands, and the United States. [1] Surveys were conducted in each of three types of schools: elementary schools (those with a 5th grade), middle schools (those with an 8th grade), and high schools (those with the last year of secondary education). Within each school sampled, the principal, a computer coordinator, and several teachers completed questionnaires. At that time, nearly 100 percent of schools in the United States had some access to computers. Advanced 16- or 32-bit computers were found to be rare all over the world.

In 1992, the survey was repeated in the aforementioned five countries, and in eight more. In addition, the 1992 study also tested over 69,000 students in grades 5, 8, and 11 in 2,500 schools to assess their practical computer knowledge. Western European students had the highest scores, followed by American students, then Japanese students. The Western European countries in the study have a formalized computer education curriculum, while the United States does not. Japan only recently has introduced computers into its educational program.

Results from the survey indicate that the United States leads the world in raw number of school computers as well as in computer density (the ratio of computers to students). However, because American schools started introducing computers years before most other countries, they now have many more older 8-bit machines. If countries are compared on the median percentage of their school computers that are 16- or 32-bit computers, the United States falls well below the other countries.

[1] Twenty-three countries participated in the 1989 study, and 13 m the 1992 study Currently, published data are available for the 1992 survey of these five countries.

SOURCE: Ronald E Anderson (ed.), Computers *in American Schools 1992: An Overview,* IEA Computers in Education Study (Minneapolis, MN: University of Minnesota, 1993)

those in current inventory are older 8-bit models, as discussed below.

Projections based on these data indicate that as of spring 1994, the number of computers used for instruction in K-12 public and private schools totaled about 4.95 million.[7] During the last three years, the total number of computers in schools has risen by about 18 percent annually-about 700,000 more computers per year---compared with an annual net of about 15 percent during the 1980s.[8] Further projections suggest that by spring 1995, instructional computers in the United States will number about 5.8 million units----or approximately one computer for every nine students.[9]

Age *and Power of Computers*

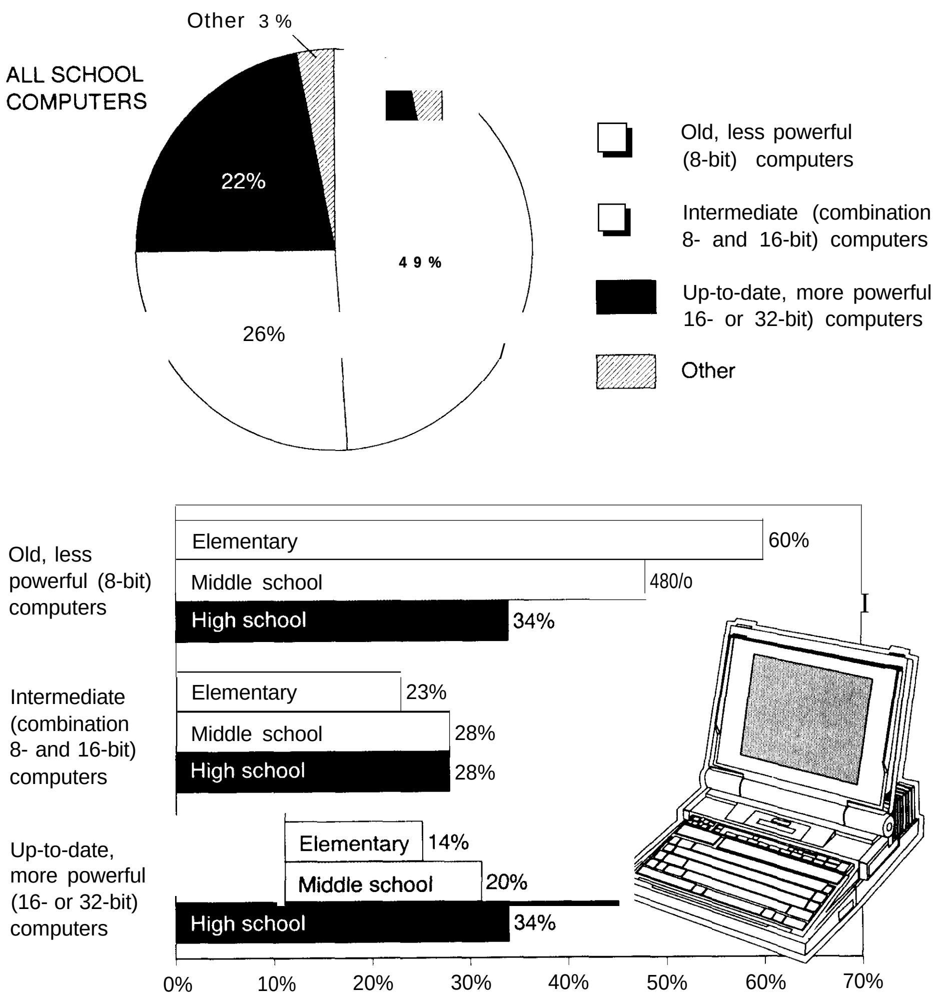
Over the past decade, most schools have acquired computers incrementally, making purchases on different occasions. Consequently schools often

[7] Ronald E. Anderson, "Hardware Projections in K-12 schools," technical memo from the IEA Computers in Education Study, University of Minnesota, Oct. 22, 1994. Projections based on 1992 IEA data, op. cit., footnote 2, and Quality Education Data, *Technology in Public Schools,* 1993-94 (Denver, CO: Quality Education Data, 1994).

8 Although industry sales indicate about 1 million units are sold each year, the instructional inventory only increases by 700,000 because schools discard some and use some mainly for administrative purposes.

[9] Anderson, op. cit., footnote 7.

FIGURE 3-3: Inventory of School Computers by Age/Power of Computers, 1992



[a] Includes primarily Apple II+, IIc, and IIe.

[b] Includes the Apple IIgs and IBM XT8088.

[c] Includes the Mac 6800, Mac 11, Mac LC, AT 80286, 386, and 486

SOURCE: R.E. Anderson (cd.), *Computers in American Schools 1992: An Overview* (Minneapolis, MN: University of Minnesota, 1993),

have machines of varying age and power. The 8-bit Apple II computer, the most popular computer marketed to K-12 schools for use in instruction in the 1980s, still comprises a large portion of school computer inventories even though it is no longer made and cannot run most newer software. As of 1992, one-half of the computers used for instruction in the United States were **8-bit** computers, primarily Apple IIs. An additional 26 percent were somewhat more powerful but still comparatively limited computers with 16-bit processors and 8-bit transmission buses (see figure 3-3). 10 Most new software being designed today cannot run on either of these types of machines.

[10] These machines include the Apple IIgs and the IBM XT 8088.

Outdated inventories are particularly pronounced in elementary schools. The number of newer 16- and 32-bit computers has grown most rapidly at the high school level, where the inventories have been shifting fairly quickly away from Apple II and toward IBM PC-compatibles. (Many school districts moved Apple IIs from high schools into elementary schools.) In 1992, over 40 percent of the elementary schools had no computers newer than Apple IIs.[11]

Why are there still so many Apple II computers in K-12 schools? First, until recently their unit costs remained lower than the more powerful 16-bit models. Second, until only four or five years ago, more software aimed at the school market was available for the older model computer. And third, schools tend to continue to outfit labs and classrooms with more of the same kind of computers they already own, to accommodate all the students in a classroom at the same time or within a reasonable period.

Enhanced Capabilities and Peripherals

In the brief history of personal computers, there have been several technological advances that might be called "order-of-magnitude" improvements—changes involving a 10-fold increase in speed, miniaturization of components, or a 10-fold improvement in capabilities. For example, at the beginning of the 1980s, floppy disks quickly replaced audiocassettes as input-output storage devices because they enabled users to access data at least 10 times as fast. Obvious examples today are the 16- and 32-bit computers whose order-of-magnitude increases in RAM memory and speed accommodate much more complex software than older machines; slowly these newer models are displacing 8-bit computers in schools.

Four other order-of-magnitude improvements in personal computers have the potential to revolutionize computer use in schools: hard disk storage, LANs that connect computers within the school building, CD-ROMs, and laser printers. The first three each promise 10-fold or greater increases in access to programs and data beyond the typical floppy-disk-based computer. Laser printers—especially in conjunction with LANs—promise substantial improvements in both the speed and appearance of printed output. All of these innovations have been widely implemented in business settings. What about in schools?

With hard disks and LANs, teachers and students can store program and data files without worrying about the mechanics of loading programs from diskettes. As of spring 1992, hard disks and LAN-connections were each available on about 20 percent of all K-12 school computers. Based on current purchasing trends, the Office of Technology Assessment estimates that at least 25 percent of school computers have both LANs and hard disks today, and perhaps one-third now have one or the other.

LANs are somewhat less prevalent in elementary schools than in high schools: 16 percent of elementary school computers were part of a LAN compared with 24 percent of high school computers. Similarly, hard disks are found much more often on high school computers. As of 1992, 30 percent of high school computers had hard disks compared with only 12 percent of elementary school computers.[12]

CD-ROM drives allow storage of and easy access to large amounts of data, including text combined with detailed illustrations, animation, sound effects, and spoken language. Schools are at a much earlier stage in acquiring CD-ROM storage than hard disks and LANs, although CD-ROM drives are among the fastest growing computer peripherals. According to one survey conducted during the 1992-93 school year, 44 percent of U.S. public schools had at least one computer equipped with CD-ROM, nearly triple the percentage found two years earlier; as with other computer technologies, high schools were more

[11] Anderson, op. cit., footnote 7.

[12] Hard disks and LAN data from 1992 IEA survey, op. cit., footnote 2.

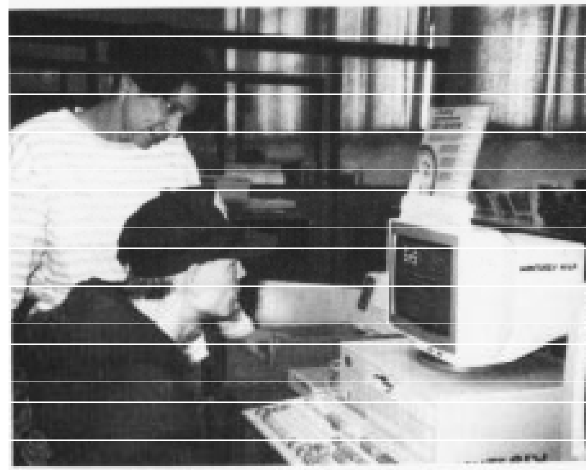
likely to have CD-ROM than elementary schools (see figure 3-4).[13] Unfortunately, surveys have not yet collected data on the number of school computers equipped with CD-ROM, nor on whether computers so equipped reside on a network, what levels of schools have them, or how much they are used. CD-ROM equipped computers tend to be placed in the school library or media center, to make them accessible to a larger number of students and teachers.

Since the mid-1980s, when teachers and students began using computers as word processors, schools have also invested heavily in printers. In 1989, for example, schools had one printer for every three computers, although more than 90 percent of these printers were the slower dot-matrix kind. Four years later, dot-matrix printers still made up nearly 90 percent of the inventory of school computer printers. Between 1989 and 1992, high schools acquired an average of one laser printer, but they also acquired seven more dot-matrix printers per school. Even less change occurred at elementary and middle school levels. In 1992, only one-sixth of elementary schools and one-third of middle schools had a laser printer for teacher or student use, compared with about two-thirds of high schools.[14]

Together these data suggest that some of the more promising uses of computers by teachers and students-desktop publishing, mathematics instruction using analytic graphing and calculating software, information-gathering from CD-ROM encyclopedias or network databases-can only be accomplished in a limited way, if at all, on most of today's school computers.

Location of Computers

As discussed above, the speed, memory, and peripherals available on school computers affect the ways teachers use them in their teaching and professional activities. Another key factor that affects how teachers use computers is the location of the computers within the school building. Placing several computers in a common location, such as a computer lab, enables teachers to use computers with the whole class simultaneously, but also makes it more difficult for teachers to integrate computer activities with other learning activities throughout the day. When computers are in labs, teachers lack the easy access needed to use them as an everyday tool or resource. About one-half of all computers used for instruction in 1992 were located in centralized computer labs, while about 35 percent were located in teachers' classrooms. The rest were placed in other special instructional rooms, libraries, offices.[15] As schools' inventory of computers continues to grow, more computers will probably be placed in classrooms, although experience from the past decade suggests that this is likely to occur gradually.



CALIFORNIA MODEL TECHNOLOGY SCHOOLS PROJECT—MONTEREY

About half of all public schools have at least one computer with a CD-ROM drive. They are often placed in central locations like this high school library

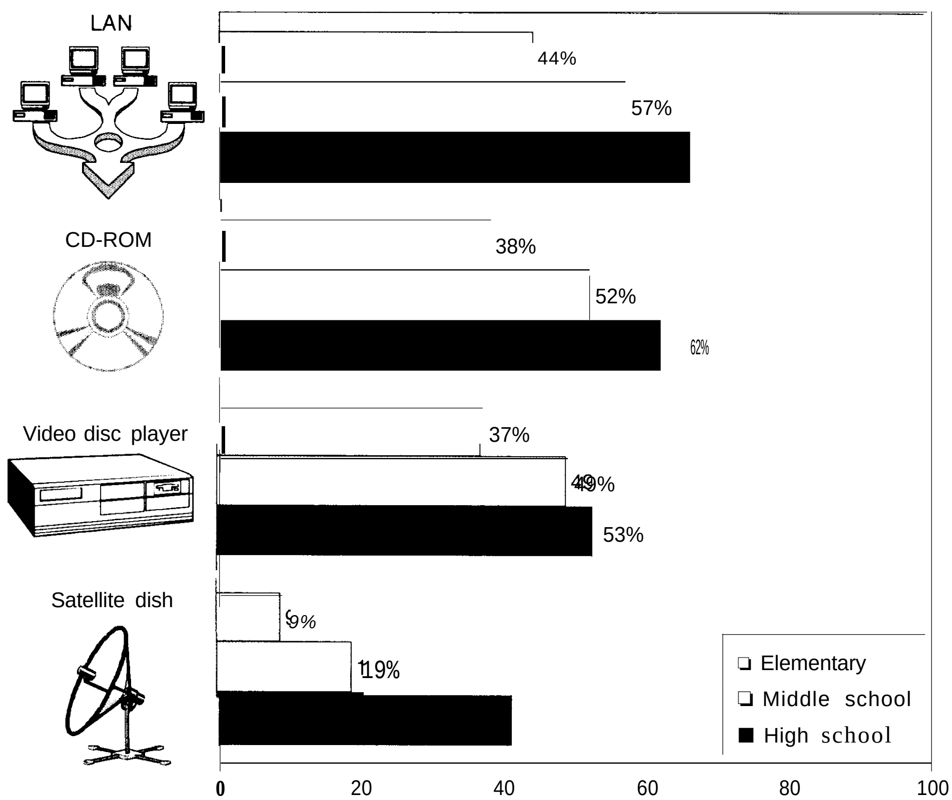
OTA site visits suggest that schools with a substantial inventory of technologies are investing increasingly in laptop computers, which can be moved around the school building and taken home

[13] Market Data Retrieval, *Educational Technology 1993: A Survey of the K-12 Market* (Shelton, CT: Market Data Retrieval, 1993).

[14] IEA data, op. cit., footnote 2.

[15] Ibid.

FIGURE 3-4: Percentage of Public Schools Owning Specific Technologies, 1993



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

by teachers and students. Some schools place their laptops on carts that can be wheeled around to make any teacher's classroom into a temporary computer lab. [16] No data are available on the number of laptops currently owned by schools. Similarly, some districts and states are investing in computers for teachers (workstations) equipped with software and tools commonly needed by teachers. Again, no systematic data are currently available on teachers' access to this kind of resource.

Differences in Computer Resources Among Schools[17]

The student-computer ratio[18] gives some indication of how many students have to share a computer. This ratio has declined dramatically over the

[16] See, e.g., John R. Mergendoller et al., "Case Studies: Exemplary Approaches to Training Teachers To Use Technology," contractor report prepared for the Office of Technology Assessment, September 1994.

[17] Unless otherwise indicated, the data in this section are taken from Ronald E. Anderson et al., *Computers in American Schools 1992: An Overview,* International Association for the Evaluation of Educational Achievement Computers in Education Study (Minneapolis, MN: University of Minnesota, 1993).

[18] The number of students enrolled in a school divided by the number of computers available for students to use.

past 10 years; as of 1992, United States schools averaged one computer for every 13 students. Closer examination of available data suggests, however, that there is enormous variability in student-computer ratios from school to school. For example, there are vast differences between schools with the lowest "computer density" (in the 20 percent of schools with the fewest number of computers per capita) and those with high computer density (in the 20 percent of schools with the largest number of computers per capita). For example, elementary schools with high computer density average only seven students sharing a computer, while those with low computer density average 35 students sharing a computer (see table 3-1).

There is also a wide range in student-computer ratios across states-varying from a low of eight students per computer in Wyoming to 22 per computer in New Hampshire (see figure 3-5). This variability may reflect the fact that some schools, districts, and states launched large-scale technology initiatives over the past several years, while others have emphasized different educational reforms, placing less emphasis on computer acquisition.[19]

Another way of looking at whether computers are equitably distributed is to compare the student-computer ratios of schools having different demographic characteristics. Using the most representative national data available, this kind of analysis shows that the most pronounced differences in computer density among schools at the same level (e.g., comparing elementary schools with each other) are between small schools and large schools. **Schools with fewer students tend to have many more computers per capita.** Statistical analysis suggests that these differences are not simply due to differences between urban and rural schools. For example, in middle schools,

Placing computers together in a computer lab is common and supports some forms of instruction. Teachers also need computers and other technologies in the classroom if they are to use them regularly as teaching tools.

where the differences are most pronounced, small schools have approximately 14 students per computer, while large schools have 24 (see table 3-l). This pattern of more resources in smaller schools also holds for video equipment such as VCRs and televisions.[20] This finding may reflect the tendencies of many districts to allocate technology funds on a per building basis, rather than a per student basis. It could also reflect commitment to providing every school building with what is viewed as a "critical mass" of technology (e.g., 30 computers for a lab).

The percentage of minority students in a school has a different relationship to student-computer ratios across the three school levels. While there are small differences among elementary schools with different proportions of minority children (see table 3-l), there are no differences among

19 Ronald E. Anderson, "State Technology Activities Related to Teachers" contractor report for the Office of Technology Assessment, Nov. 15, 1994.

20 CPB data, op. cit., footnote 3.

TABLE 3-1: Average Student-Computer Ratios in 1992 by Computer Density, School Control, School Size, and Percent Minorities

	Elementary	Middle	High School
Computer density[a]			
Lowest 20%	34.5	35.5	31.4
Middle 60%	15.8	14.0	10.4
Highest 20%	7.2	5.4	3.7
School control			
Private	20.5	18.2	15.2
Public	17.5	15.1	11.9
School size[b]			
Small	'15.9	14.4	11.5
Large	22.5	24.3	17.1
Percent minorities			
0-3%	16.7	14.0	12.5
4-24%	18.6	16.2	12.5
25-100%.	18.7	18.3	12,4

[a] Schools were di vided into three groups based on the computers per capita. "Highest 20%" refers to the 20% of schools that have the most computers per capita, "Lowest 20%" refers to the 20% of schools with the fewest number of computers per capita.

[b] The dividing point between small and large schools was at an enrollment of 500 students at the elementary level, 700 students at the middle school level, and 1100 students at the high school level,

SOURCE: R.E. Anderson (cd.), *Computers in American Schools 1992: An Overview,* (Minneapolis, MN: University of Minnesota, 1993), table 2,3, p. 17.

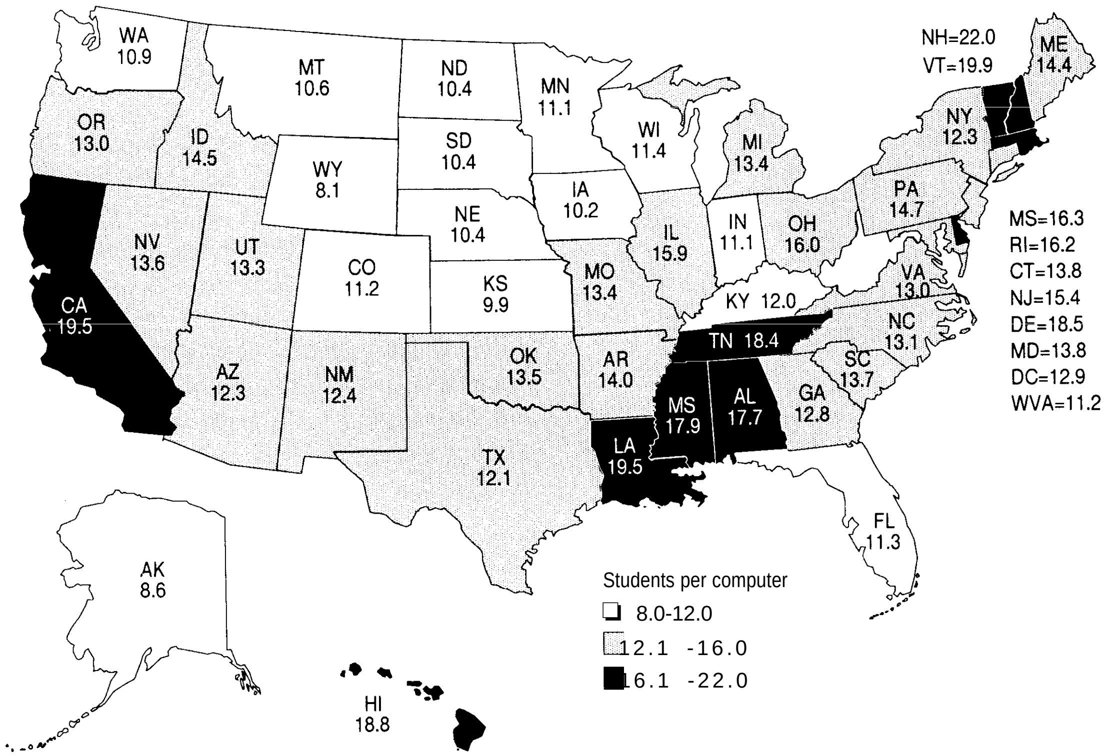
high schools. The largest differences appear in middle schools, where schools with less than 4 percent minority enrollments have an average of 14 students per computer, while schools with more than 24 percent minority enrollments have 18 students per computer.

Ratios of students to computers do not indicate which students within the schools have access to and experience with computers. Research done in the 1980s found that in the early years of computer adoption in schools, poor and minority students had less access to computers both at home and at school. In addition, data showed small gender differences favoring boys over girls in access to computers in school.[21] Some recent data from the IEA study suggest that while girls are still somewhat less likely to report using computers at school or receiving instruction in computers, ethnic minority students are slightly more likely than white students to report having had these opportunities. The authors of this report write:

> The advantage of ethnic minority students over white students will come as a surprise to those who read the statistics from previous studies in the early to mid- 1980s. Further investigation of the forces behind this pattern is needed, but we might speculate that the minority advantage at the 5th- and 8th-grade levels stems from the success of programs like Chapter One which

[21] See Rosemary E. Sutton, "Equity and Computers in the Schools: A Decade of Research," *Review of Educational Research,* winter 1991, vol. 61, No. 4, pp. 475-503.

FIGURE 3-5: Average Number of Students per Computer by State, 1994



NOTE: Students per computer is a measure of how many students have to share a computer. Smaller numbers (e.g., 8.0) mean that fewer students have to share a computer.

SOURCE: Quality Education Data, *Technology in Public Schools, 1993-94* (Denver, CO: 1994).

fund the purchase of new technology to be used with disadvantaged students.[22]

How Much Do Students Use Computers?

There are few reliable data about how much the 4 million-plus computers in schools are actually being used; the only estimates are rough ones. One problem is that reports of use vary greatly depending on the source. For example, using reports of computer coordinators and making certain assumptions about shared use of computers (i.e., that one-half of the time students share a computer with a peer, and both are profiting from its use simultaneously) yields the following estimates:

- Computers are used about one and three-quarters hours per student per week at elementary schools.
- Computers are used approximately two hours per student per week at middle schools.

[22] Anderson, op. cit., footnote 2, p. 81.

ACOT/APPLE COMPUTER, INC.

Schools are beginning to invest in laptop computers because of the flexibility they provide. These students use computers like books or notepads, taking them wherever they go.

- Computers are used approximately three hours per student per week at high schools.
- On average, computers are used about two hours per week per student across all school levels.[23]

The students themselves, however, report much less frequent use:[24]

- 24 minutes per week in grade 5,
- 38 minutes per week in grade 8, and
- 61 minutes per week in grade 11.

At most, this is only one-third of the time estimated from the coordinator reports. There are several possible explanations. School computers may be sitting idle much more than the adults reported; students may be underestimating their experiences; some students may be having rather intensive computer experiences while the rest are having more limited, occasional, or exploratory ones. Available data do not provide answers to these questions.[25]

The data from both the coordinators and the students suggest that, in the aggregate, older students who use computers to any significant extent use them two to three more times during a typical week than younger students do. However, universality of use—providing experience with computers to all students-is more likely at younger grade levels. For example, student data suggest that 74 percent of all 5th graders used computers during the year on more than a few occasions, in comparison to 57 percent of llth graders.

How Many Teachers Use Computers?

Data on the number of teachers who use computers vary greatly depending on how one defines a "computer-using teacher." Two different definitions-one quite inclusive, the other much more stringent-yield very different estimates. In addition, these definitions have focused on use of computers for direct instruction with students only; no data are available on other teacher uses such as administrative tasks or professional development.

In the 1992 IEA survey, a "computer-using teacher" was defined liberally as a teacher who "sometimes" used computers with students. Using this broad definition of how much teachers themselves report using computers, 75 percent of 5th-grade teachers, and about half of 8th- and

[23] Based on the 1992 IEA data, these estimates are, of course, averages and do not indicate whether all students have this same experience with computers or whether some students monopolize their use—either because of their own preferences, the course-taking patterns of different students, or the assignment practices of different teachers.

[24] In the Becker contractor report for the Office of Technology Assessment (see footnote l), the estimate of total computer time for a student was made by adding the number of occasions of computer use the study reported for each of nine subjects. Answers were coded according to grade level. Each occasion was multiplied by the number of minutes estimated for that grade level, and the total number of minutes was divided by 30, representing the roughly 30 weeks that had elapsed during the school year up to the time the questionnaire was completed.

[25] Another possible reason for the apparent inconsistency between teacher and student reports is that many teachers may have *some* (but not all) their students in a class or some (but not all) of their classes use computers, or they allow students to do so at their option without systematically requiring computer use of all students.

11th-grade teachers were found to be "computer-using" teachers.

A more stringent way to define "computer-using" teachers is to include only those teachers who clearly required most or all students to do work on computers.[26] Under that definition, about one-half of 5th-grade teachers, one-third of 8th-grade English teachers, and one-fifth of 11th-grade English teachers qualify—roughly 20 to 30 percentage points fewer than under the other definition. If an even more stringent criterion is employed, one related to frequency of use,[27] the percentage of teachers who identify themselves as "computer using" is even lower—about one-third the size of the original group. **Thus, the percentage of teachers classified as computer-using teachers is quite variable and becomes smaller as definitions of use become more stringent.**

Instructional Uses of Computers by Teachers

Over the past decade, the advice of "experts" in educational technology about what teachers *should* do with computers has been constantly changing—from BASIC programming, to Logo programming, to tutorials provided by integrated learning systems, to generic computer applications such as word processing, to activities integrated with existing curricula, to student-developed multimedia presentations, and now to telecommunications-based learning communities[28] (see box 3-2). **According to survey data, however, when teachers are using technology for instruction they do so in much more traditional ways.**

For example, IEA survey data indicate that the most common activities on computers for elementary students have been drills in basic skills and instructional games. Also popular at all levels are general "computer literacy" activities: use of various instructional programs and generic computer applications such as word processing. School computer coordinators estimate, for example, that students spend the most computer time learning to type on computer keyboards and use word-processing programs. Interestingly, the estimated share of computer time students spend on mathematics declines between elementary school and high school from 18 to 8 percent, suggesting that math teachers are using computers primarily for students to practice arithmetic skills rather than to solve higher-level mathematics problems. Between 1989 and 1992, the one significant change in the allocation of student computer time was a one-third decline in the time spent teaching students computer programming as a part of computer literacy education.

Available data suggest that in secondary schools, computers are used relatively infrequently for teaching and learning in traditional academic subjects, far less than in classes focused on teaching students *about* computers.[29] Although most middle-school and high-school students reported using computers for at least one academic subject, for most subjects, this meant using computers only once or twice over most of the school year. If one examines only those classes for which students had used school computers on at least 10 occasions during that

[26] The criterion used by Becker (see footnote 1) was that at least 90 percent of a teacher's students actually have used computers for their class as reported by the teacher. This presumably counts only those cases where students use computers at the teacher's instruction rather than totally on their own initiative.

[27] For example, when the class is using computers, a typical student will do so at least once during the week; or during the school year an average student will have had six experiences using any one of several types of software such as word processing, "print shop" programs, or desktop publishing.

[28] Henry Jay Becker, "Computer Experience, Patterns of Computer Use, and Effectiveness—An Inevitable Sequence or Divergent National Cultures?" *Studies in Educational Evaluation*, vol. 19, 1993, pp. 127-148.

[29] IEA Student data, op. cit., footnote 2.

BOX 3-2: Timeline of Changes in the Prevailing Wisdom of "Experts" About How Teachers Should Use Computers in Schools

1982

Teachers are told to:	**Teach students to program in BASIC.**
Rationale:	"It's the language that comes with your computer. "

1984

Teachers are told to:	**Teach students to program in LOGO.**
Rationale:	"Teach students to think, not just program. "

1986

Teachers are told to:	**Teach with integrated drill and practice systems.**
Rationale:	"Individualize instruction and increase test scores. "

1988

Teachers are told to:	**Teach word processing.**
Rationale:	"Use computers as tools, like adults do. "

1990

Teachers are told to:	**Teach with curriculum-specific tools (e.g., history databases, science simulators, data probes).**
Rationale:	"Integrate the computers with the existing curriculum. "

1992

Teachers are told to:	**Teach multimedia hypertext programming.**
Rationale:	"Change the curriculum—students learn best by creating products for an audience. "

1994

Teachers are told to:	**Teach with Internet telecommunications.**
Rationale:	"Let students be part of the real world."

SOURCE: H.J. Becker, "Analysis and Trends of School Use of New Information Technologies, " Off Ice of Technology Assessment contractor report, March 1994.

school year (i.e., once every three weeks since the survey 'was completed 30 weeks into the school year), more than one-third of secondary school students reported using computers this often in a computer class, but for other subjects the percentages were much lower: 9 percent for an English class, 6 to 7 percent for a math class, and only 2 to 3 percent for a social studies or science class. Since word processing is a major activity in secondary school computer education classes as well as in business education classes, it seems clear that high school is still primarily a place to learn how to use word processing, rather than a place where teachers have students do word processing in order to achieve other academic goals. This is even more likely for other applications, such as spreadsheets and database programs, which have been less integrated by teachers into subject-matter instructional practices than word processing.

At the elementary school level, the survey data suggest that students use computers overwhelmingly in an exercise mode-doing drills and playing various kinds of games with instructional content—rather than in a productivity mode, using computers as a tool to

solve problems or create products. For example, 53 percent of 5th graders said that they used school computers to play games on 10 or more occasions during that school year, while 13 percent said they did word processing. Similarly, about 65 percent of 5th-grade teachers report that computers in their classes are mainly used for language arts skills practice and games, while 18 percent say they are used primarily for writing and word processing; about 17 percent report both categories of use.

Video Technologies

The past several years have witnessed a growing interest in teaching that uses video as a resource. This is due, at least in part, to the expansion of cable programming with educational content, the widespread availability and familiarity with videocassette recorders, developments in computer-based video, and an increase in the supply of videodiscs for schools.

For the next several years, the basic projection mechanism for video will likely remain the television set or the composite (computer) monitor. Nearly every school in the country has at least one TV set for use in the instructional program. According to a 1991 survey of public schools, the mean number of sets per school was 12; the median per school was seven sets.[30]

Unlike the case for computers, the availability of television sets is nearly the same among elementary, middle/junior highs, and high schools. In 1991, there were slightly more than four television sets for every 10 full-time teachers at each of those levels. In a 1993 survey, 41 percent of teachers reported having a television set in their own classrooms.[31]

Almost every school in the United States has at least one VCR. As of 1991, the mean number per public school was 6.3, or one for every 1.9 televisions. As with televisions, elementary, middle, and high schools have about the same number of VCRs per capita. The typical school has one for every five teachers.

Teachers use VCRs for showing commercially produced videos and for recording programs from cable or broadcast television and showing them later. Most schools maintain a library of prerecorded cassettes. Based on Corporation for Public Broadcasting (CPB) data, 67 percent of teachers reported that they record shows at home for school use, and many others said that they ask other school personnel to make recordings for them.

It is interesting to note that, unlike most surveys on computers in schools, data on video and television are given at the classroom level, or per teacher, rather than per student. This may reflect the fact that, unlike computers, video technologies are seen more as technologies to be controlled by the teacher, who presents information to groups of students or the entire class, rather than technologies operated by individual students.

Cable and Satellite Connections

Teachers have an increasing number of sources of video programming beyond prerecorded cassettes, educational broadcasting, and recordings made at home. Between 1991 and 1993, there was a 25 percent increase in the proportion of schools with direct cable connections,[32] so that now as many as three-fourths of all schools have cable somewhere in the school building. Another survey found that roughly one-third of all teachers in the sample reported having cable TV service in their own classroom.[33] "Access to cable" can mean different things to different schools, however, depending on the channels carried by the local cable provider and the type of service to which

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[30] CPB survey, op. cit., footnote 3. The large difference between mean and median suggests that while most schools have a few television sets, a small minority have made a substantial investment in televisions, enabling most teachers to have one in their rooms.

[31] NEA Communication Survey, op. cit., footnote 4.

[32] Market Data Retrieval, op. cit., footnote 13, p. 140.

[33] NEA Communications Survey, op. cit., footnote 4.

Unlike videotape, which must be played in a linear fashion, videodiscs allow students and teachers to browse through, capture, and play video images in any order

the school subscribes.[34] One study, for example, reported that, although 61 percent of schools reported having access to the Public Broadcasting System (PBS), and almost as many had access to national commercial broadcast networks, far fewer had access to commercial cable channels that offer a number of educational programs, such as the Discovery Channel (35 percent) or the Learning Channel (16 percent).

An increasing number of schools and districts are obtaining satellite dishes, giving them a wider selection of programming than that offered by their local cable distributor. According to one report, the proportion of schools directly accessing satellite broadcasts nearly doubled between 1991 and 1993.[35] As of 1993, 50 percent of all school districts reported having a satellite dish as did 17 percent of all public schools. High schools are more likely to have satellite dishes than are middle or elementary schools (see figure 3-4).[36]

One contributor to the recent growth of satellite dishes in middle and high schools has been the Channel One project created by Whittle Communications, Inc. (and now owned by K-III Communications). Whittle installed satellite reception systems in schools that committed to show students "Channel One," a daily 12-minute news program, which includes two minutes of commercials. Each participating school also received two VCRs and enough 19-inch television sets to put one in each classroom.

By the spring of 1993, three years into the program, approximately 12,000 schools were receiving Channel One, according to Whittle. A three-year evaluation report of Channel One translates this to mean an audience of over 18 million teens, or almost 40 percent of the 12-to 18-year-olds enrolled in school.[37] With these participation numbers, the Channel One offer seems to have contributed substantially to the installed base of video technologies in middle and high schools throughout the country. Some evidence suggests that this impact may be greater in poorer school districts. One survey found Channel One participation to be higher among districts with a poverty rate exceeding 25 percent than in districts with poverty rates under 5 percent (42 percent vs. 25 percent).[38]

Videodisc Players

Teachers use instructional videodisc differently than they use videotapes. Teachers commonly videotape programming to show in a linear format; for example, to have students watch a 10-minute instructional television segment or an hour-long program from beginning to end. An

34 Andrew Russell, CPB, personal communication, Dec. 9, 1993.

35 Market Data Retrieval, op. cit., footnote 13. The specific rate of increase reported was 85 percent.

36 Ibid., and CPB survey, op. cit., footnote 3.

37 Jerome Johnston and Evelyn Brzezinski, *Taking the Measure of Channel One: A Three Year Perspective* (Ann Arbor, MI: University of Michigan, Institute for Social Research, January 1994).

38 MDR, op. cit., footnote 13.

instructional videodisc, by contrast, usually contains many thematically related but short (under 3 minutes) discrete segments of action and still video. The teacher or student can access and directly control the segments of visual and audio materials. Using a remote control, barcode reader or computer equipped with hypermedia software, the teacher can browse through, access, and play different segments of video in any order—using them, for example, to illustrate and enhance a presentation or discussion.

The number of public schools with at least one videodisc player doubled between 1991 and 1993, to 41 percent.[39] During that period the variety of educationally appropriate videodisc software increased substantially, and at least two states allowed videodiscs to appear on the list of "texts" approved for adoption as options to printed textbooks. As with many other technologies, more high schools report having a videodisc player than do middle and elementary schools (see figure 3-4).

Still, in terms of access, the question is not whether a school *has* videodisc equipment but, rather, what proportion of teachers *can use* the videodisc equipment without difficulty. In a 1991 survey of teachers, only 12 percent reported that they had videodisc players readily available to them in their schools. Furthermore, less than half of those teachers reported actually using the videodisc regularly for instruction (see figure 3-1).[40]

Camcorders

Camcorders and other video equipment allow students and teachers to undertake new kinds of learning activities, such as making their own video reports or recording student presentations. Most schools have at least one camcorder; as of 1991, this was true of 80 percent of elementary schools and 90 percent of middle and high schools. Some 8 percent of all schools even had their own TV studio in 1991, including 22 percent of high schools. But not every school makes this equipment available to teachers or students. According to one survey, just slightly more than half of the schools with camcorder or studio facilities used these for student instructional activities, including giving students production experience or feedback on their own performance in a classroom activity.[41]

How Much Are Video Technologies Used in Schools?

Available data on teachers' use of video resources reflect conditions in the spring of 1991.[42] For televisions, VCRs, and other video resources whose use has been reasonably stable over time, the 1991 information is still useful; for videodisc, CD-ROM, and emerging technologies where use is expanding quickly, the 1991 data are clearly insufficient.

Most teachers in the United States make some use of video-based instruction during the year.[43] In the CPB survey, about 80 percent of U.S. teachers said they had used instructional television or video some time during the school year. About one-half of all teachers (51 percent) said they had used TV or video in teaching in the past month. The teachers most likely to have used video recently are elementary school teachers and secondary science and social studies teachers.

Estimates derived from the CPB data suggest that across all subjects, secondary students, on average, spend one and-one-half hours per week watching video material in school. The average

[39] MDR, op. cit., footnote 13, p. 81

[40] NEA, op. cit., footnote 6, pp. 53-54.

[41] CPB survey, op. cit., footnote 3.

[42] Ibid.

[43] Although the survey questions specifically asked about "video," use of film media was not explicitly addressed in instructions to teachers, making it difficult to know how much film use is incorporated into these statistics.

elementary student is estimated to watch video in school for slightly more than one hour per week.

Technologies for Two-Way Communication

The instructional technologies discussed above are used primarily to transmit information or to help develop student competencies. But it is another function of instructional technology where applications are expanding rapidly—to facilitate two-way communication, allowing teachers and students to share their ideas, questions, and productions with the world outside of their school. **As schools attempt to make learning more meaningful to students and to anchor it in "real world" examples and experiences, more and more educators are looking for technological tools that help teachers and students to communicate with the outside world.**

Schools are acquiring and exploring a range of technologies and tools that facilitate two-way communication. These include new ways of using older technologies such as telephones, facsimile machines (fax), and modems; combinations of different technologies, such as distance-learning systems; and new kinds of telecommunications hardware, software, and services. Because many of these latter applications are so new in schools and are expanding so rapidly, up-to-date survey data about access are not available. However, some data have been collected about telephones, modems, fax machines and distance-learning technologies in schools; these are discussed below.

Telephones and Fax Machines

Telephones and fax machines are two communications resources with great potential for teaching and learning; too often, however, they usually are accessible only to school administrators. Access to telephones, in particular, is currently a major technology issue being discussed by teachers' organizations. **Although one-third of all teachers in a recent survey felt it was "essential" to have a telephone in their classroom, only one teacher in eight had a telephone in the classroom that could be used for outside calls**. Less than 1 percent had access to voice mail. Most teachers have to make calls from the school office or a faculty lounge, where many colleagues share a phone and most conversations cannot be held in private. Sixty-three percent of teachers surveyed felt it is "essential" for parents and teachers to be able to contact one another during the school day; almost three-quarters of teachers feel that having telephones in the classroom would improve parent-teacher communication at least "somewhat."[44]

Among the reasons for restricting teachers' access to phone services are concerns about costs and unregulated use. Installation and monthly charges tend to be prohibitive for a restricted school budget, in part because phone companies often charge schools higher-priced business rates for installation and message unit charges.[45]

Teachers seem less interested in having access to fax machines. Although approximately one-fourth of teachers had access to a fax machine in their school, most did not view it as an important instructional resource.[46] Since fax machines are relatively rare in schools, it is likely that most teachers are not aware of their instructional or administrative potential.

Modems

Modems, which allow computers to communicate electronically across a telephone line ("telecomputing"), have been available almost from the be-

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[44] NEA Communications Survey, op. cit., footnote 4.

[45] Edmund L. Andrews, "MCI Plans To Enter Local Markets," *The New York Times*, Jan. 5, 1994, p. D1; and U.S. Congress, Congressional Budget Office, *Promoting High-Performance Computing and Communications* (Washington, DC: U.S. Government Printing Office, June 1993), pp. 39-43.

[46] NEA Communications Survey, op. cit., footnote 4.

ginning of personal computing.[47] Although many districts have modems, they were originally dedicated primarily to administrative uses. With the advent of new educational applications of electronic networking, however, modems have become an important gateway to telecomputing.

In recent years schools have begun installing more modems for teachers to use for instructional activities. For example, in the 1989 IEA survey, slightly more than one-fourth of U.S. schools had a modem that could be used by teachers or students. By 1992, that percentage had grown to 38 percent overall, including 60 percent of all high schools, 35 percent of middle schools, and 33 percent of elementary schools.[48]

As with other technologies, the presence of a modem in a school building does not tell much about the average teacher's access to telecomputing. Many teachers may consider access to a modem anywhere in the school sufficient for the occasional special project. Over the long run, however, if telecomputing is to be used regularly, classroom access to a modem or alternative connection will be necessary.

Distance-Learning Technologies

The most established educational technologies for two-way communication are those used in distance learning. For more than a decade, schools have used live one-way video technologies via satellite or broadcasting in conjunction with two-way audio (via phone lines) or other two-way media such as computer networks or fax machines to expand learning opportunities. Some distance-learning projects also involve two-way video communication through microwave or fiberoptic transmission. Distance learning is most often used by schools in remote, rural, or sparsely populated areas and by other schools that lack traditional educational resources, such as a qualified teacher for a low-enrollment course. Distance-learning technologies allow high schools, for example, to offer courses, such as advanced calculus, Japanese, and Russian, that may not be available otherwise.

The prevalence of distance learning is difficult to estimate, in large part because its definition is inexact and inconsistent. In a 1991 survey, about 17 percent of districts reported having some capacity for live video with interactive capabilities.[49] Another survey found that in the 1992-93 school year, 28 percent of districts had some distance-learning capability and that 11 percent of all schools were involved in distance-learning—double the number from their data taken two years earlier.[50] In this survey, high schools were much more likely to have distance-learning capabilities (25 percent) than either middle (10 percent) or elementary (8 percent) schools, probably because high schools use it to offer advanced courses for which they may not have enough students to hire a qualified teacher.

In about 70 percent of the districts with distance-learning capabilities, two-way interaction is limited to voice-only interactivity through dial-up telephone lines,[51] an arrangement that allows only a small number of the participating classrooms to communicate on-air with the studio video instructor during a given class period. About 20 percent of districts' distance learning employs two-way video. Available surveys do not assess the number of classes or students using distance learning for a portion of their instructional time.

[47] Wireless modems, using cellular technology, are also now available. Their use in schools is still very limited, due to the expense of initial purchase costs and the costs of per minute charges when used for connecting to networks outside the building.

[48] IEA data, op. cit., footnote 2.

[49] Calculated from CPB data, op. cit., footnote 3.

[50] Market Data Retrieval, op. cit., footnote 13. District percentages from the MDR file are, however, questionable because of the low response rate in that survey.

[51] Ibid., and CPB Survey, op. cit., footnote 3.

A camera mounted on the computer takes pictures or videos of learners at one site and sends them to students at other locations, adding a personal touch to collaborative group work.

However defined, the use of distance learning in K-12 settings has increased considerably in the last several years. While fewer than 10 states were participating in distance-learning projects in 1987, virtually every state is now involved with distance learning in some way. In addition to using distance learning for student instruction, many states and districts use it for videoconferencing, teacher training, and professional development (see chapters 4 and 5).[52]

Technologies for Linking to Wide Area Networks and the Internet[53]

There are several possible ways schools can link up with wide area networks (WANS) in general, and the Internet in particular (see box 3-3). The options for telecommunications connections are shifting, as individual modem dial-up connections give way to more sophisticated and higher speed connections to WANs and the Internet; these options include connections via LANs, high-speed phone lines, dedicated connections, and so forth. Other models of connectivity include Integrated Services Digital Network (ISDN), satellites, digital cable, or other linking technologies. Several connectivity formats are described briefly below; however, no national data are currently available regarding how many schools and districts are using any of these options.

Direct single modem dial-up

Connectivity often begins with a pioneering individual teacher making personal connection to a network through a dial-up modem-in some cases a regular telephone line and a computer outside the classroom, in the principal's office or the library. The teacher might access any of several services with different features: one aimed primarily at Internet connection (e.g., the World Wide Web); one that seems easy to use, such as America Online; a state-level network, such as The Texas Education Network (TENET); or a special interest network such as EcoNet for ecology. Most dial-up services now offer some form of Internet connectivity, and through that, access to other services, a factor that is gradually reducing earlier problems with unconnected networks.[54]

LAN-Internet (director indirect) without video

To reach the Internet directly, a user must go through an Internet node. Nodes are allocated by regional network providers who provide networking hardware as well as the electrical connection.

[52] Market Data Retrieval, op. cit., footnote 13.

[53] Much of this section is taken from TERC, "Review of Research on Teachers and Telecommunications" contractor report prepared for the Ofice of Technology Assessment May 1994.

[54] However, it is important to note that "Internet connectivity'' comes indifferent levels, starting with e-mail only and progressing through access to file transfer, Wide Area Information Servers (WAIS), and other services. Dial-up services have to support each major server function like these separately, and are quickly augmentig their services. However, "full" Internet connectivity of the kind that would support video may not be practical through dial-up providers for some time.

Some schools have established their own Internet node and server at a school and connect that to the school's LAN. The server can be a point of presence on the network where resources of value within the school can be published. As of December 1994, there were 189 Internet sites in K-12 schools.[55] For example, the Ralph Bunche School in Harlem has its own Internet server. A single low-speed data-only line (e.g., 56 Kilobits per second (kbps)) is sufficient to support multiple users, providing they do not require video or heavy use of high-bandwidth services, such as the World Wide Web (WWW).

Other schools avoid the costs of an Internet node by using an indirect connection; that is, connecting their LAN to another one nearby that has Internet connectivity. This nearby connection could be a district headquarters, a college, the high school, or a friendly business. Again, a 56-kbps dedicated line can support a few dozen teachers who use relatively simple applications.

LAN-Internet with video

Sending video images over networks requires substantial bandwidth and entails higher costs than other options. Networking capacity that handles digital video will also increase the performance of all other kinds of networking. In addition, there are new kinds of network-based multimedia presentation software, such as WWW browsers like Mosaic,[56] that can be used only over networks with video capacity, even if they do not use video. An Internet connection through a "T-1"1.5 Mbps (megabits per second) line connected to a school LAN could support the entire school.

Although many network services are currently offered via single modem dial-up, dedicated access to the Internet is becoming increasingly attractive because, although it entails higher costs up front, it may be more cost-effective and certainly less limiting in the long run. Furthermore, these connections can support multiple users simultaneously, offer access to many of the most innovative and high-powered telecomputing innovations, and serve as a common mode of access to a broad range of electronic communities.[57]

Despite the advantages and growth of alternative connectivity scenarios, few schools currently have any connectivity options. In those that do, most are still using a single phone line connected to a dial-up modem and computer. **A lack of telephone lines in schools and especially in classrooms is cited as the greatest barrier to teachers' participation in electronic communities**.[58] As discussed above, many of the telephones that do exist in schools often serve administrative purposes and are not available to teachers for classroom use or for making outside calls to networks. For example, a recent study of TENET reports that "84,683 phone jacks were in Texas' 1,058 school districts. However, only 2 percent of the classrooms had access to a phone line."[59]

[55] Gleason Sackman, Coordinator, SENDIT, North Dakota State University, personal communication, December 1994.

[56] *Mosaic* refers to a class of software tools that originated with the National Center for Supercomputer Applications' Mosaic. Several software tools are now available with similar functions.

[57] For example, see Yvonne Marie Andres, "Hello Internet: Tools for the Classroom, Comparison of Internet Connectivity Options," Global School Net Foundation, Bonita, CA, May 1994.

[58] Margaret Honey and Andrés Henríquez, *Telecommunication and K-12 Educators: Findings from a National Survey* (New York, NY: Center for Technology in Education, Bank Street College of Education, 1993).

[59] WEB Associates, "TENET After One Year," paper presented at the annual meeting of the Telecommunication in Education Association, February 1993.

BOX 3-3: Telecommunications Terms and Concepts

The creation of networks for microcomputers ushered in a new era in the development of computers. Computer networks use electronic pathways (wired or radio-based) to connect one computer with other computers, enabling a person at one terminal to communicate with other people, to transfer information electronically, and to use computers in a distant location.

Local area networks (LANs) consist of computers connected together in the same physical area, usually within one building. LANs can be connected to other LANs, expanding the people and computers with whom users can communicate. Networks of computers able to communicate over larger distances are called wide area networks, or WANs. LANs are often a building block for a WAN. WANs may span cities, states, or even continents; most are closed systems set up for a specific group of users (e.g., private corporate networks or state networks). The Internet is neither a LAN nor a WAN but an "Internetwork"---a network of networks that share a common set of protocols. It provides access to databases and networks around the world. LANs are typically used to share resources, such as printers, and to deliver instructions; schools typically use WANs or the Internet to access external resources. '

The most common network connection for K-12 educators to state networks or the Internet is typically made by using a modem and a telephone line. The modem modifies the digital information used by the initiating computer so that it can pass across telephone lines. Another modem at the other end restores the information to a digital form that can be used by the receiving computer.

Information Services

A variety of information services with varying levels of sophistication are available to help people communicate and transmit information across computer networks. To use an information service, a computer must have client software to communicate with the server software at the other computer.

The most common services of computer networks are electronic mail (e-mail), transfer of computer files, and remote log-in. E-mail allows the user to send messages to another person, a group of people (a list), or an electronic forum (also called an electronic bulletin board) where many people can read them. Computer networks also let users copy and transfer electronic files from a computer where they are stored, called the server, to the user's machine. These files may be written documents, maps, graphics, images or video, or software files. Remote log-in enables a user at one location to use a computer at a distant location for such activities as searching through library catalogues or making airplane reservations. These three services are the building blocks of more sophisticated applications of networks. Some types of connections may support only one or two of these three basic uses; for example, a connection may permit sending e-mail to a distant colleague but may not support transferring files from that colleague's computer.

One popular service is a chat room. In a chat room, messages entered by any user immediately show up on the screen of all users, and a written record of the conversation is maintained. Chat rooms are a form of synchronous communication (participants must be available at the same time); e-mail, by contrast, is an example of asynchronous communication (users can communicate on their own schedules).

A small but growing number of teachers are gaining access to other kinds of information services available through the Internet, such as Gopher, World Wide Web, and Wide Area Information Servers (WAIS). These services enable people with Internet connections to view and transfer files or to access extensive databases (e.g., articles, graphics, software, current weather and weather forecasts, or stock market prices). The basic prerequisites for access include the appropriate client software and a modem or other

[1] See Denis Newman et al , "Local Infrastructures for School Networking Current Models and Prospects," Technical Report No, 22 (New York, NY Bank Street College of Education, Center for Technology in Education, May 1992)

BOX 3-3 (cont'd.): Telecommunications Terms and Concepts

connection to a WAN; in addition, the WAN must support the desired service. "Internet connectivity" can take place at many different levels. Some WANs have restricted connections to the Internet that allow only certain kinds of services, such as exchanging e-mail or using Gopher but not using World Wide Web or WAIS.

A IAN or WAN that is fully connected to the Internet will support any of the varied and growing services that follow Internet protocols—procedures defining how to make new services work over the Internet—and will allow users to link with any other computer that is also fully connected.

Organization and Support Structure

As yet, there is no one organization responsible for administering or supporting the Internet, so getting support in the use of Internet services has been a problem for teachers. Organizations that currently provide teachers with connections have only limited support for beginners and have given little thought to helping beginners acquire the necessary client programs. Some help is available, however, in the form of books, electronic documents, and commercial products that combine books and ready-to-use software.[2]

Some support structures do exist. For each electronic community of teachers, whether organized around a curriculum project or a topic of mutual interest, there is typically a group that provides the organization and a support structure to help define that community. Typically, the group provides such elements as a name, a registration procedure, a framework of expectations, a timeline, print or electronic materials, and support services. Examples of organizing structures include: curriculum projects, such as AT&T Learning Circles, NGS Kids Network, and TERC's Global Laboratory; discussion groups, such as the Consortium for School Networking (CoSN); and programs, such as NASA's Spacelink.

Educators can access information services through either commercial service providers, such as America Online, CompuServe, Prodigy, Delphi, and Apple's eWorld; or through nonprofit service providers, such as state-supported networks. Both commercial and nonprofit providers are actively soliciting participation of teachers, schools, and districts. While these organizations do not presently provide full connectivity to Internet resources, they do offer extensive support to users. Some of the state networks have text-based menu systems. Commercial providers use graphical software to support inexperienced users and provide extensive user support through e-mail, answers to frequently asked questions (FAQs), and an "800" number. They also have designed ways to minimize connect time (the time when the phone line is actually in use), thereby keeping down the cost of their services.

[2] For example, Ventana Media has published the "Internet Membership Kit, " which includes a set of Internet client programs, required protocols, and documents for both Mac and Windows platforms Purchase entitles the user to free Internet account setup, one month's free service, and SIX hours of free online time through an Internet service provider.

SOURCE: TERC, "Review of Research on Teachers and Telecommunications," Office of Technology Assessment contractor report, May 1994

Faster modems and LANs that enable multiple users to connect to outside networks at the same time are not yet commonly available in schools. A 1990 survey of 485 California schools reported that only 11 percent had access to wide area network services as well as a local area network; none of these schools used their LAN to distribute data from the WAN.[60] Although these data are surely

[60] Denis Newman et al., "Local Infrastructures for School Networking: Current Models and Prospects," Technical Report No. 22 (New York, NY: Bank Street College of Education, Center for Technology in Education, May 1992).

out of date by now, they suggest a problem that remains significant nationally:

> Teachers' and students' access to the educational services now appearing on the Internet is problematic, because few schools have information infrastructures capable of routing data to individual classrooms. Unlike higher education, K-12 institutions typically have neither host computers powerful enough to allow direct access to the Internet nor a web of telephones and modems that could enable individual Internet usage through dialing up a provider. Further, many schools do not have networks that transmit data around the entire building, and the networks in individual classrooms often have such low bandwidth that sending educational material from computer to computer is very slow. Interconnecting different types of networks within a school or district is also a complex technical challenge.[61]

State-Level Networks

An increasing number of states are organizing and funding state networks for teachers and students and sometimes for other public agencies and businesses. In a 1993 survey, 33 states reported supporting one or more telecomputing networks, for K-12 instruction.[62] Six more states had a partially operational network, and nine more had one in the proposed or planning stages (see figure 3-6).

Some of these networks use a design whereby teachers dial into local computers, which in turn process and store messages. These local computers are placed to maximize the number of teachers who can reach them through local rather than long-distance telephone calls. Most state networks aim to provide services at little or no charge to teachers. For teachers who are not local—a significant proportion—"800" numbers are often provided at substantial expense to the state.

State networks vary considerably in their scope, purpose, sophistication, and support services. Among the most ambitious are Virginia's PEN (see chapter 5), which aims "to guarantee access to the Internet to every public school educator at no charge,"[63] and TENET (see box 3-4).

Many states have established networks with gateways to other networks. For example, Florida's Information Resources Network (FIRN) provides free electronic (e-mail) to all educators and a menu that offers access to many Internet-based services. FIRN also supports distance-learning services, an automated card catalog, a technical assistance system, staff development teleconferences, and satellite-delivered training for teachers.[64]

Other states have established less ambitious networks, offering such services as e-mail lists, news groups, and computer conferencing. Indiana, for example, supports both a statewide fiber-optic network for education called Intelnet, and a bulletin board called IDEAnet for educator communications, conferencing, and database access. Montana administers the Montana Educational Telecommunications Network (METNET), connecting individual schools with Distance Learning Centers, Regional Training Centers, and Compressed Video Sites. Oklahoma encourages schools to link up to SpecialNet, a network designed to facilitate special education. New Jersey Link (NJLink) served over 4,000 teachers in 1993,

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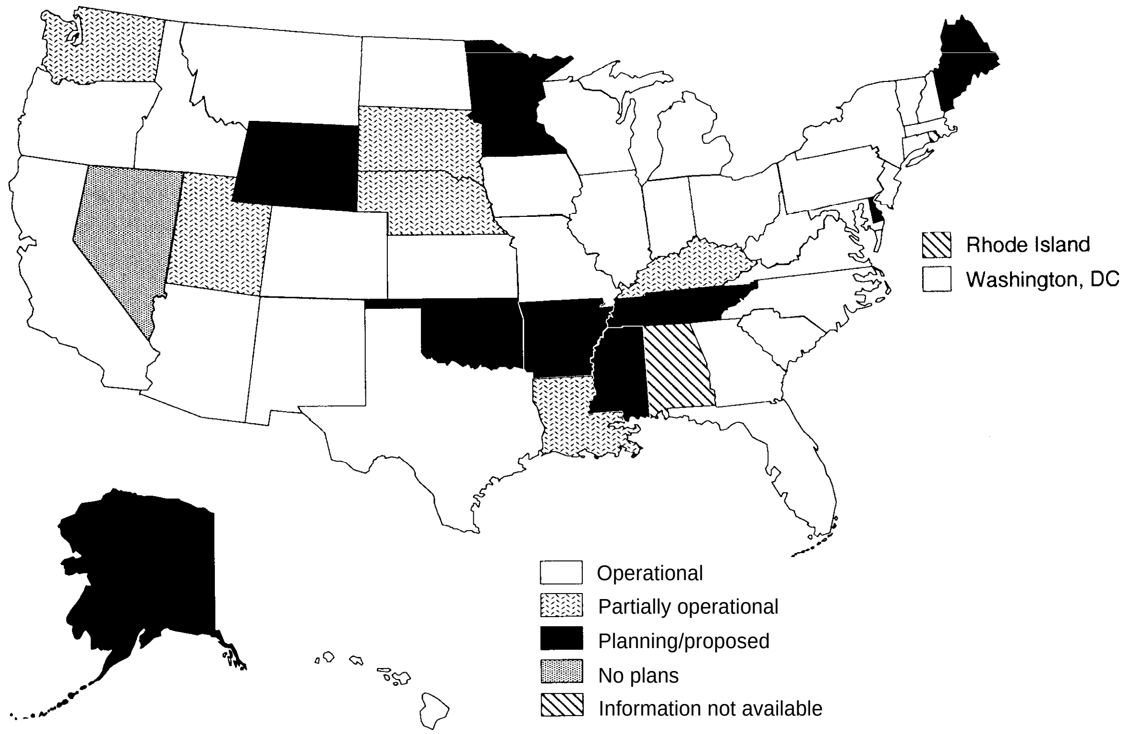
[61] Chris Dede, "The Technologies Driving the National Information Infrastructure: Policy Implications for Distance Education," paper commissioned by the Southwest Regional Laboratory in connection with the U.S. Department of Education's Evaluation of Star Schools, October 1994, p. 11.

[62] Educorp Consultants Corporation, *Networks Now: The 1993 Survey of How States Use Telecommunication Networks in Education* (Roanoke, VA: Educorp, 1993).

[63] Glen L. Bull et al., "Considerations Underlying the Architecture of a State Public School Telecomputing Network," *Consortium for Educational Telecomputing: Conference Proceedings*, Robert F. Tinker and Peggy M. Kapisovsky (eds.) (Cambridge, MA: TERC, Apr. 18-19, 1991), pp. 121-134.

[64] Anderson, op. cit., footnote 19.

FIGURE 3-6: Status of State Support for K-12 Instructional Telecomputing Networks, 1993



SOURCE: Educorp Consultants Corp., *Networks Now. The 7993 Survey of How States Use Telecommunication Networks in Education* (Roanoke, VA: 1993).

offering free information resources, communication with other educators, and other network services.

Other Networks

Other networks in which educators participate have been organized by school districts, communities, and the private sector. School districts use networks to foster districtwide educational goals and to link with local and out-of-town electronic network resources. While district networks often include only such services as exchanging e-mail within the district, posting messages on bulletin boards, and reaching the Internet with e-mail, some are more ambitious. The Boulder Valley Internet Project, for example, is a collaboration of the local university and the school district that aims to link as many schools as possible with high-speed connections and to encourage teachers to use these resources. Similar efforts are under way in other districts.[65]

Community-based electronic networks link many of the functions of community life with one another. In these electronic communities, anyone in the geographic area served can participate. As of January 3, 1995, there were 130 of these local

[65] Rrports about other district projects can be found in Kenneth M. King and John Clement, EDUCOM, "Toward a National Network Infrastructure for K-12 Education: Final Report on a Fact-Finding Mission," unpublished manuscript, 1990.

BOX 3-4: The Texas Education Network (TENET)

With 40,000 participants and a 1993 average of 100,00 log-ons per month, the Texas Education Network (TENET) is among the largest and most successful state efforts to open the world of telecommunications technology to teachers. Established in 1989, TENET aims to provide connectivity to all educators and students in the state via a local or 800-number telephone call. The University of Texas in Austin operates TENET via the THEnet (Texas Higher Education Network) backbone and houses its central resources and operations staff.

Teachers in grades K-12 pay $5 per year for an account; university faculty and teacher education students pay $25. Participants receive such services as e-mail, news groups, conferencing, file transfer, curriculum guides, Internet gateway, and access to national, state, and local user groups.

Several aspects of TENET support preservice education and professional development for teachers. Through special interest groups, teachers can share information and discuss educational issues. TENET also has online training and maintains information files on a range of topics pertinent to teachers.

Among the most notable features of TENET is its major teacher training component. The network maintains 80 master trainers from all regions of the state. Master trainers provide support to school technology coordinators, Regional Education Service Center (RESC) support staff, and others. They also communicate regularly on a TENET special interest group and provide workshops and other training sessions for teachers. Among the training issues addressed are how to join electronic teacher groups for professional development, how to locate and download instructional materials, and how to use telecommunications to involve students in global projects or collaborative writing.

The state has steadily increased its financial commitment to TENET since its creation, and in FY 1994 invested about $2.5 million in the network's operation. In FY 1995, the state will spend $4.5 million on the network. As TENET becomes more popular, Texas is grappling with how to meet demands for additional phone lines and storage space at reasonable cost.

SOURCES: J.R. Mergendoller et al., "Case Studies Exemplary Approaches to Training Teachers To Use Technology, " Office of Technology Assessment contractor report, September 1994; Educorp Consultants Corp., *Networks Now: The 1993 Networks in Education* (Roanoke, VA: Educorp, 1993); Connie Stout, Director, TENET, personal communication, November 1994; Geoffrey Fletcher, Interim Executive Deputy Commissioner for Curriculum, Assessment, and Professional Development, Texas State Department of Education, personal communication, January 1995.

FreeNets in 42 states, according to an online survey.[66] These networks offer bulletin boards for students sharing work, expedite inquiries to local public agencies, facilitate information sharing and research, provide local databases, and so forth. With over 35,000 registered users and over 10,000 log-ins per day, the Cleveland FreeNet, operating out of Case Western Reserve University, is probably the largest community network in the world and a model for community-based networks.[67] The network provides users with everything from e-mail services, to information about health care, education, technology, recreation, law, auto mechanics, or just about anything else the host operators would like to place on the machine. Anyone in the community with access to a home, office, or school computer can connect to the sys-

[66] Elizabeth Reid, National Public Telecomputing Network (NPTN) survey, Jan. 3, 1995.

[67] Doug Schuler, "Community Networks: Building a New Participatory Medium," *Communications of the ACM*, vol. 37, No. 1, January 1994, pp. 40-48; and Sister Dolores Stanko, National Public Telecomputing Network and Community Computing, distributed over e-mail by the Cleveland FreeNet, on Dec. 12, 1992.

tem, 24 hours a day, and use these services. All of it is free and all of it can easily be accomplished by a first-time user.

Not surprisingly, community-based networks face the challenge of developing viable models of low-cost network services that are accessible to all community members. Some keep costs low by offering users access to larger networks for the cost of a local telephone call.

Use of Telecommunication Networks

Reasonably current national survey data provide some information concerning the school use of telecommunications hardware and software for information gathering, electronic mail, and collaborative instructional work. In the 1992 IEA survey, data collected at the school level indicated that in 10 to 15 percent of schools at least one teacher used electronic mail/information networks (e.g., Compuserve); usage was higher at the high school level than in elementary schools. Approximately the same percentage of high schools reported using online databases such as Dialog. IEA also asked separately about two instructional programs involving telecomputing—AT&T Learning Circles and the National Geographic's Kids Network. According to the survey, AT&T Learning Circles had been tried in about 4 percent of schools nationwide at all levels, and the K-8-oriented Kids Network garnered participation in 6 percent of elementary schools and 3 percent of middle schools. Altogether about 20 percent of schools reported using one or more telecommunications service. However, no information was available about the number of teachers using the service at any given site.

A year later, the 1993 NEA Communications Survey inquired of its sample how many teachers had ever participated in a "learning network at school, such as the AT&T Learning Network or the National Geographic Society's Kids' Network" (6 percent had); whether the respondents were currently engaged with their students "in an on-line collaborative teaching or distance learning [activity]" (4 percent were), and whether they "had access to" public electronic mail and information utilities such as Prodigy (19 percent), Compuserve (14 percent), America Online (7 percent), and Dialog (9 percent). In addition, 4 percent said they had access to the Internet through their school. Altogether, nearly 25 percent of the NEA sample of responding teachers reported having access to at least one of these telecommunications services. While the NEA sample is not representative of the U.S. teaching population,[68] if the same percentage were applied to all U.S. schools, it would mean that as many as 600,000 teachers nationwide were involved in telecomputing.

The extent of telecomputing activity among teachers is not well understood—especially now as potential opportunities for participation are mushrooming. Furthermore, although the number of telecomputing teachers is growing rapidly, these data indicate that the great majority of U.S. teachers still do not have access to telecommunications services.

Telecommunications Software[69]

In addition to access to hardware, teachers' participation in electronic communities is often determined by the ease of use and functionality of available telecommunications software. According to TERC, to meet the needs of teachers, telecommunications software should have the following features: a user-friendly ("point-and-click") interface (see figure 3-7); network connectivity among multiple computer systems (MS-DOS, Macintosh, etc.); multiple options for connectivity, including the Internet; the capacity to send formatted nontext enclosures, such as graphics, spreadsheets, and data video images; the ability to enable the *same* message or formatted data to be sent to multiple parties who use diverse

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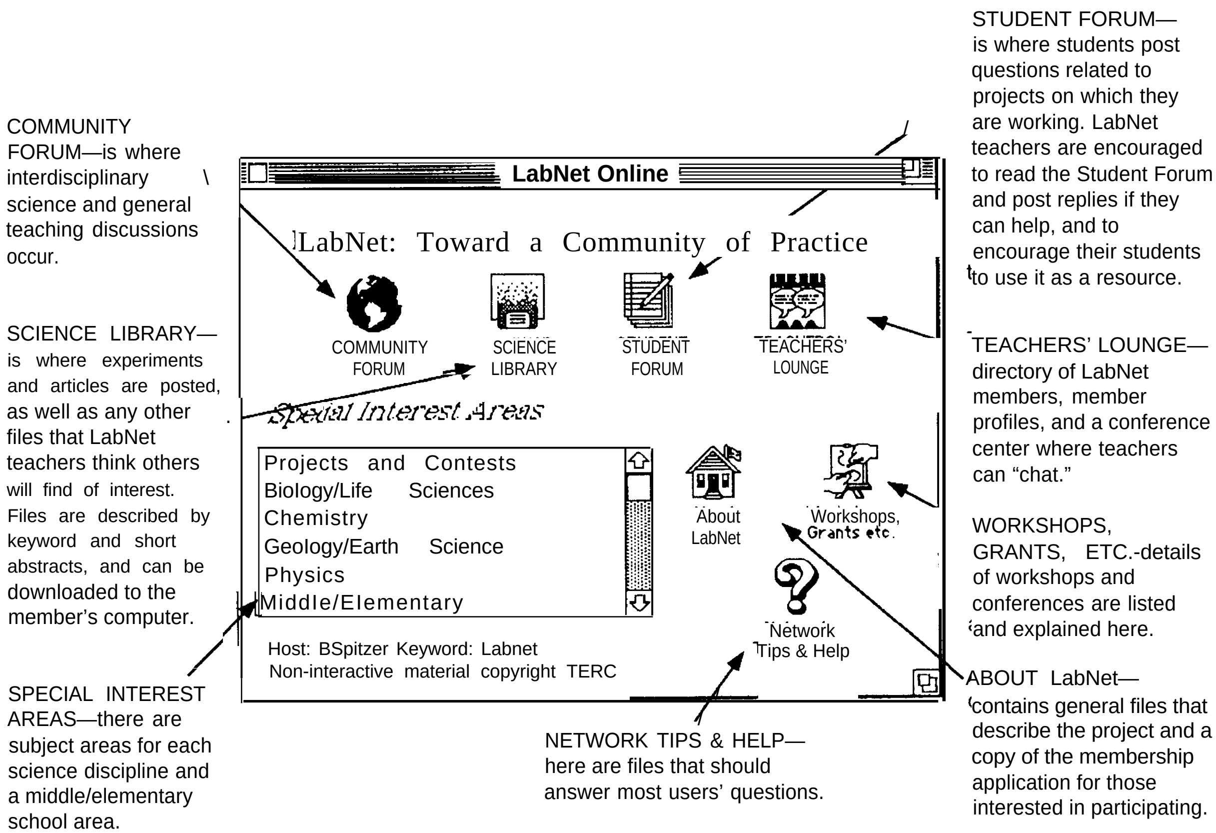
[68] The NEA survey excludes teachers from most large city districts and others that are not NEA members (see appendix B).

[69] Much of this section is taken from TERC, op. cit., footnote 53.

FIGURE 3-7: America Online's LabNet Main Screen



SOURCE: TERC, "Review of Research on Teachers and Telecommumcations," contractor report prepared for the Off Ice of Technology Assessment, 1994

software and hardware configurations; the ability to download and manipulate files at user computers without re-formatting; and be capable of being easily updated.

There are a growing number of Internet-based telecommunications software tools for information searching and retrieval. NCSA Mosaic and other similar tools are among the most powerful because they provide a user-friendly means of connecting with World Wide Web and Gopher resources on the Internet. The Web includes online documents that consist of text, images, sounds, video, and animation on a range of topics, such as Gaelic texts, art exhibits, movie clips, and electronic magazines. Documents can include footnote like links to other files, so that by pointing and clicking, the user can move from one document to retrieve relevant information from other documents located elsewhere on the Internet. In addition, the telecommunications functions in the Mosaic interface are automated so as to be nearly invisible to the user. However, Mosaic is useable only through a direct, relatively high-speed connection, and this type of connection is still rare in school settings.

Telecommunications, with the access it can provide to resources beyond the classroom walls, has considerable educational potential. Yet the evidence reviewed here indicates that most schools are not equipped to participate in these opportunities.

STATE POLICIES ON ACCESS AND USE

State policies can be an important influence on teacher use of technology. A telephone survey and review of state literature done under contract to OTA indicates that states have taken diverse approaches to addressing the challenge of educational technology.[70] This section summarizes some of these data. (See, also, chapter 4 for discussion of state technology policies related to inservice teacher training and chapter 5 for state policies on teacher certification and technology.)

State Staffing for Technology

One way that states can influence local technology use is through state staffing and support for educational technology. Staffing policies vary considerably across states. In one state, the educational technology coordinator is an associate commissioner; in others, a part-time consultant. Some coordinators are located within a media division, others in an instructional technology unit, and some in a telecommunications office. Some state educational technology units have budgets in the many hundreds of million dollars; other states fund little more than a single staff person.

Technology Integration

All but seven states reported that they require or recommend integrating computers or information technology into the curriculum (see table 3-2). About 25 percent of the states actually mandate the integration of computer technology across the curriculum. For instance, the Iowa Legislature in 1993 established an Educational Technology Consortium charged with developing technology plans for the state that ensure "equity of access" and assist schools with the integration of hardware and software into their curricula. However, the way technology is to be integrated is less clear. **In fact, some states continue to equate technology policy with mandating courses about computers rather than assisting teachers to learn to teach with a range of technologies.**

Computer Courses for Students

Twelve states require that public schools offer computer-related courses such as keyboarding or computer literacy, while an additional 20 states recommend to districts that such courses be offered. For example, since 1984 Arkansas has required high school students to take a one unit course in "computer science;" a new plan to be implemented in 1996 requires Arkansas schools to offer more advanced, elective computer science courses as well. Washington State law requires that each school district provide an opportunity for high school students to take at least one course in "computer education," or allow students to take it in another district.

Student Computer Competency

Today 19 states mandate computer competency requirements for graduating seniors. Additionally, as states define and set new achievement standards consistent with the Goals 2000: Educate America Act (see chapter 6), many are attempting to address skills students will need to work with technologies. Maine law stipulates that schools make instruction in the use and application of computer skills available to secondary students and requires each student "to demonstrate proficiency in the use of computers that include loading, operating, and applying fundamental skills. This may include word processing, keyboarding, developing a data base, accessing data, and using software."[71] Maine recommends that technology be built into the curricula in grades 7 or 8, but leaves it up to the districts to establish their own plans and procedures. Utah requires that every high school student be computer literate before graduating, which students may demonstrate by

[70] Anderson, op. cit., footnote 19.

[71] Dennis Kunces, *Planning Guide for High School Diploma Computer Proficiency Requirement* (Augusta, ME: Maine Department of Educational and Cultural Services, 1989).

TABLE 3-2: State Education Technology Policies, September 1994[a]

State name	Promotes technology integration in curriculum (1)	Requires computer course for students (2)	Mandates computer competency for students (3)	Requires computer training for teacher certification (4)	Requires inservice technology training (5)	Students per computer (6)
Alabama	✓		✓		✓	17.7
Alaska	✓					8.6
Arizona	✓			✓		12.3
Arkansas	✓	✓		✓		14.0
California	✓			✓		19.5
Colorado				✓		11.2
Connecticut	✓					13,8
District of Columbia	✓		✓	✓	✓	12,9
Delaware	✓					18.5
Florida	✓					11.3
Georgia	✓					12.8
Hawaii	✓		✓			18.8
Idaho	✓					14.5
Illinois						15.9
Indiana	✓					11.1
Iowa	✓					10.2
Kansas	✓			✓		9.9
Kentucky	✓					12.0
Louisiana	✓		✓			19.5
Maine	✓		✓	✓		14,4
Maryland	✓		✓			13.8
Massachusetts	✓			✓		16.3
Michigan	✓			✓		13.4
Minnesota	✓					11.1
Mississippi	✓	✓	✓			17,9
Missouri	✓					13.4
Montana	✓					10.6
Nebraska	✓		✓			10.4
Nevada		✓	✓			13.6
New Hampshire	✓	✓		✓		22,0
New Jersey	✓		✓	✓		15.4
New Mexico	✓		✓	✓		12.4
New York	✓					12.3
North Carolina	✓		✓			13.1
North Dakota						10.4
Ohio	✓			✓		16.0
Oklahoma	✓	✓	✓	✓		13,5
Oregon	✓		✓			13,0
Pennsylvania	✓		✓			14.7
Rhode Island	✓	✓	✓			16.2

TABLE 3-2 (cont'd.): State Education Technology Policies, September 1994[a]

State name	Promotes technology integration in curriculum (1)	Requires computer course for students (2)	Mandates computer competency for students (3)	Requires computer training for teacher certification (4)	Requires inservice technology training (5)	Students per computer (6)
South Carolina	✓					13,7
South Dakota	✓	✓	✓			10,4
Tennessee	✓	✓		✓		18.4
Texas	✓	✓	✓			12.1
Utah	✓	✓	✓			13.3
Vermont	✓					19.9
Virginia	✓		✓			13.0
Washington	✓	✓		✓		10,9
West Virginia	✓	✓		✓		11.2
Wisconsin	✓			✓		11.4
Wyoming				✓		8.1

[a] An ' ✓ ' in the column means a state has that policy A blank cell means that the policy does not exist.

The definitions of the column check lists areas follows:

(1) State requires (or recommends) that public schools integrate computers or information technology in the curriculum

(2) State requires that public schools offer computer-related courses such as keyboarding or computer literacy

(3) State has a mandate for computer competency or performance standards for students related to information technology

(4) Teacher certification in the state includes a requirement for training in computers or technology (see chapter 5)

(5) State has a requirement for inservice computer or technology training (see chapter 4).

(6) Microdensity is defined as students per computer. (Data from QED, 1994 report on Technology in Public Schools, QED, Denver, Colorado.)

SOURCE: R.E. Anderson, "State Technology Activities Related to Teachers," OTA contractor report, Nov. 15, 1994

taking a computer literacy course or passing a test of technology-related skills and knowledge.[72]

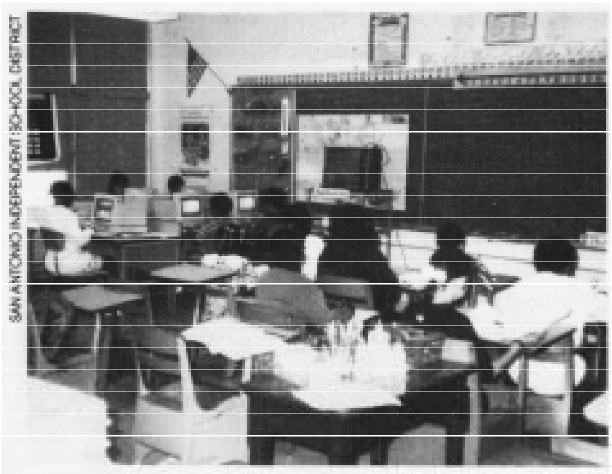
Many states, like Vermont, do not mandate technology competency, but recommend that districts make computer competency a graduation requirement. North Carolina recently has designed an innovative, detailed competency-based curriculum in technology including considerable emphasis upon "information skills." Beginning in 1995, students will have to pass a performance-based competency test.

The state survey suggests that the amount of educational technology hardware in a state is not correlated with the state's tendency to establish requirements in either student technology competency or in teacher technology training. Therefore, OTA finds that the relative amount of computer technology available in a state should be used with great caution as an indicator of that state's commitment to technology in instruction (see table 3-2).

CONCLUSION: ISSUES WITH POLICY AND RESEARCH IMPLICATIONS

The data examined in this chapter suggest several themes, issues, and questions that have implications for future policy decisions and research

[72] Utah State Board of Education, "Elementary and Secondary Core Curriculum Standards," Instructional Technology, Utah State Board of Education, Salt Lake City, UT, n.d.



Classrooms such as this one, with five computer workstations as wall as a television monitor, offer teachers flexibility in teaching with technology Many states are seeking funding to provide this level of technology access in all classrooms.

agendas. This section discusses the importance of developing anew definition of access to technology, the importance of two-way communication, additional research needed for policymaking, and strategies for better understanding effective instructional practices.

■ A New Definition of Access

One overarching theme emerging from the data presented throughout this chapter is the need to begin thinking differently and more critically about what constitutes "access" to technology by teachers and students. Conventional data on infrastructure-numbers of computers in a school, student-computer ratios, and school ownership of various kinds of video and telecommunications equipment—are insufficient measures of meaningful access to technologies. **What is called for is a new way of defining access that examines the kinds of infrastructure, organizational arrangements, and other supports teachers need to use technology effectively in the classroom.**

Under such a definition, a first step might be to look at the availability of hardware and software, but in a more discerning way than just counting computers. Key factors include the age and power of hardware and the kinds of peripherals and software the equipment can support. Also crucial are the presence of connectivity hardware, software, and services. As the earlier discussion suggests, it is now possible to use the same technology in several different ways, depending on what the purpose of the user is, which kinds of software and peripherals are available, and how multiple technologies are combined or connected. It is also important not to overlook older technologies, such as the telephone (see box 3-5).

A second step might be to examine whether existing technologies are arranged and organized in a way that is conducive to frequent and effective use by teachers and students. Are different kinds of technologies located in a central place or in individual classrooms? Can existing equipment be made more mobile? Is there a LAN, and could it be used for more purposes than at present? Are certain kinds of technologies "reserved" for certain kinds of teachers and students, such as advanced-level science students or business education students? Is the hardware situated so that it can be used effectively for different kinds of instruction, such as group projects, buddy learning, or individual study or research?

A third step might be to examine the kinds of support that teachers need to use the infrastructure effectively: to integrate technology into their everyday teaching, to use technologies for two-way communication, and to use technologies to encourage the best instructional practices. These supports, discussed in more detail in subsequent chapters, might include exposure to innovative uses, high-quality professional development, and ongoing technical support and expert advice.

■ The Importance of Two-Way Communication

The potential of new technologies to facilitate two-way communication has changed dramatically in recent years and holds great promise for changing teaching, learning, and professional development. Telecommunications and networking technologies, in particular, create incomparable opportunities for teachers and students. And new hardware, such as videodisc or CD-ROM players, makes it possible to combine the excitement of

BOX 3-5: Planning for School Technology Use: Two State Examples and Cost Estimates

Technologies are used by schools for many reasons and to accomplish different goals. Technologies for teaching and learning vary in key characteristics: how richly they convey information, how suitable they are for whole classroom versus individual student use, how many pieces of equipment are required for simultaneous use by an entire class, how portable they are, how interactive and adaptable they are to individual student or teacher needs, and how flexibly they can be used by teachers in a school setting. These characteristics affect which technologies schools acquire and how they use them.

To some extent, therefore, the amount and type of hardware and software a given site "needs" depends on the educational goals it expects to meet using technology. As a part of this planning process, some states and districts are trying to designate some basic levels of technology to which each building and classroom should have access and to estimate the costs of such an infrastructure.

For example, Kentucky's Master Plan for Education Technology calls for a communication system for voice, video, and data that will interconnect all computer workstations in the classroom, school, district, office, public library, and Kentucky Department of Education with other statewide and national education networks. ' Goals for instructional technology include a telephone in every classroom, a portable teacher workstation for each of the 36,000 teachers in the state, and a computer workstation for every six students. About 100,000 additional workstations will be needed to meet the student workstation goal. Taking into account existing infrastructure that meets the standards of the Master Plan, the state estimates that $560 million will be needed to implement the plan over a period of six years.[2]

Implementation of the Kentucky plan began in 1992. The one-time costs of hardware and software will be shared equally between the state and local districts. The ongoing maintenance and operations costs at the state and district levels will be funded by the state, while local school districts will bear the maintenance costs of the system's school, classroom, and family/school connection levels.

A recent initial planning document from the New York State Department of Education outlines the potential costs of implementing a vision of an even more advanced technological infrastructure for K-1 2 schools in that state. This plan outlines the costs of putting a basic amount of new technology in every public school building throughout the state and networking them.[3] A three-stage deployment is envisioned. The first stage would put five workstations with multimedia and network links in the library-media center of each of the state's 4,016 public schools. The second stage would put one workstation in each of an estimated 187,000 classrooms and network them to a wide area network and the Internet via a broadband T-1 connection (1.5 mega bytes).4 The third, full-blown model adds four more workstations in each classroom. The table displays the technologies and costs for this three-stage deployment, as well as the estimated

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[1] Kentucky Department of Education, "Master Plan for Education Technology, " Council for Education Technology, Apr. 30, 1992

[2] Revisions to Master Plan for Education Technology, adopted by Kentucky State Board for Elementary and Secondary Education, November 1993.

[3] Existing hardware, software, and networking in schools were Ignored in this cost model. In addition, this model reflects an estimate of the total life-cycle costs, exclusive of consumable materials (e. g., printer toner and paper) and furniture for a five-year period. The Iife-cycle cost analysis takes into account not only hardware and software, but also maintenance, technical support, training, networking, and other "hidden" costs. This model particularly emphasizes the staff development and technical support components of successful technology implementations. Basic list prices are considered in the cost model, since the model's author considered it Impossible to estimate any discounts that would be applied on such a large-scale purchase. M. Radlick, "A Cost Model: Implementing Technology in New York State Public Schools—A Paper for Discussion," New York State Education Department, Albany, NY, November 1994

[4] Building wiring would be fiberoptic cable to all classrooms, and copper from thereto the desktops. Every workstation should be networked to the Internal LAN resources and out to the wide area network, including the Internet Networking and network resource must be able to support high-bandwidth applicatlons, including multimedia and interactive video from other sites. Included in the multimedia capability IS videoconferencing at the workstation level Radlick, ibid.

(continued)

BOX 3-5 (cont'd.): Planning for School Technology Use: Two State Examples and Cost Estimates

Proposed Five-Year Cost Model for Implementing Technology in New York State Public Schools

Stage of model	Technologies	Network infrastructure (per building)	First-year cost	Additional cost for the 4 remaining years in hardware lifecycle[c]	Total cost
Stage 1 Put in the library-media center of each public school building (total = 4,016)	▪ 5 workstations with software,[a] IAN, and Internet connections ▪ 1 laser printer ▪ 1 CD-ROM tower ▪ 1 color LCD projector unit	▪ 56 kb link to Internet ▪ 1 router ▪ 1 server ▪ initial cost of network connection to library/media center[b]	$371,593,000 includes about $73 million for training and support personnel	$436,991,200 includes about $233 million for training and support personnel	**$ 808,584,200**
Stage 2 Put into each classroom (total = 187,000)	▪ 1 workstation with software, LAN, and Internet connections ▪ 1 laser printer ▪ 1 color LCD panel	▪ T-1 network link ▪ initial costs of network connections to classrooms	$3,627,350,000 includes about $769 million for training and support personnel	$2,616,200,000 includes about $1.7 billion for training and support personnel	$6,243,550,000
Stage 3 Add into each classroom:	▪ 4 workstations with software, IAN, and Internet connections		**$2,992,000,000**	$1,047,200,000 no additional training and support	$4,039,200,000
Total costs			**$6,990,943,000**	$4,100,391,200	$11,091,334,200

[a] Total cost of each workstation estimated at $3,500. Workstation includes a 486 (DX2) or Pentium or Macintosh Power PC 7100 with CD-ROM and color monitor Basic operating system (Windows or System 7) assumed to be bundled. Cost = $3,000, Additional application software cost = $500

[b] The cost of network Connections is assumed to average $7,500 per Classroom, The initial network connection to the Ilbrary/media center is assumed to average $15,000

[c] Includes hardware and software maintenance (1 O percent), training, support, and cost of service across T-1 and 56-kb links

SOURCE: M Radlick, "A Cost Model Implementing Technology in New York State Public Schools—A Paper for Discussion, " New York State Education Department, Albany, NY, November 1994.

BOX 3-5 (cont'd.): Planning for School Technology Use: Two State Examples and Cost Estimates

costs for operating, maintaining, upgrading, training, and support over a five-year life cycle. The estimated total cost comes to just over $11 billion over five years.[5]

The New York state annual education budget for 1992-93 was slightly more than $21 billion. In 1992-93, New York schools spent an average of 2.2 percent of their total education budgets on technology, which includes hardware, software, network technical staff, instructional staff, and supplies and material. The total amount spent across the state that year was about $360 million.[6] Thus, fully implementing this cost model, even across a 10-year period, would require a substantial increase in the percentage of the education budget invested in technology.

[5]About 37 percent of the total is for Instructional hardware and software; 17 percent for building the network infrastructure; 21 percent for ongoing costs such as maintenance, upgrades, and line charges; 9 percent for training; and 16 percent for staff support personnel.

[6]Michael Radlick, "Technology Expenditures in New York State Schools, " unpublished draft, New York State Education Department, Dec. 7, 1994.

SOURCE: Office of Technology Assessment, 1995, based on Kentucky Department of Education, op. cit., footnotes 1 and 2, and Radlick, op. cit., footnotes 3 and 6.

video with the information transmission power of the computer and the communication capabilities of high-speed telephone.

Given these trends, connectivity is likely to become the major technology issue of the next several years. Although few up-to-date data are available, it appears that a very small percentage of teachers have access to the kinds of telecommunications and networking technologies needed, for example, to participate in a global science project, or contact distant colleagues for advice on attention-deficit disorder.

Policymakers might respond by developing new kinds of guiding principles for access to and use of telecommunications. This is already occurring in discussions at the federal, state, and local level about educator access to a "National Information Infrastructure." Other issues to be addressed include the issues of copyright, confidentiality, funding and subsidies, and limiting student access to some forms of information (see chapter 1).

Framing policies in these areas will not be an easy task, since the field of educational telecommunications is still so young and fluid. New uses for telecommunications are emerging all the time, and it is not yet clear what classroom applications are possible or most effective.

▮ Additional Research Needed for Policymaking

Help in framing policy could come from more extensive research. Available data are weak regarding the very newest technologies available to teachers—new forms of analog video and digital multimedia technologies like videodisc and CD-ROMS and new opportunities for telecommunications via computers. There are few data on how much or in what ways teachers are taking advantage of existing network access. In what ways are student-learning routines affected by the availability of telecommunications access to the outside world? How is a teacher's professional life affected by these resources? Future studies of educational technology should focus on the uses of those new media—not simply their presence, but how they affect the learning of students and the jobs of teachers.

Having access to technologies does not ensure that they will be used well. **As** noted in this chapter, more comprehensive use could be made of

the current technology inventory in schools. Evidence for restriction in current usage can be found in the persistence of drill-and-practice, games, keyboarding instruction, "computer classes," and certain kinds of video viewing. It is hard to draw clear conclusions about how existing resources could be used more comprehensively, however, because teacher use is an area where data on educational technologies are weakest. Surveys to date have collected only minimal data directly from teachers about their own access to and use of technology. Knowing that technology resources are in a school is insufficient to understand whether and how teachers are using them. Observations of and interviews with teachers could help to provide the kinds of contextual information that would illuminate many of the questions surrounding the gap between access and use.

New research might examine several issues regarding teacher use. How and why do teachers use technology in instruction across the various curricular areas? How do teachers integrate videotaped presentations, for example, in different subject matter? How are teachers using camcorders, telephones, or telecommunications links? Which resources are effective for which educational goals? To what extent do teachers use technology for other parts of their job, such as carrying out administrative tasks, participating in professional development, communicating with the world outside school, or involving parents in the schooling process?

Furthermore, the discrepancies between teacher and student reports about how many minutes students use computers, and between teachers and district-level educators about how many teachers are "computer-using" teachers, suggest the need for deeper analysis of what constitutes technology "use." How long or how intensive must an interaction with various technologies be to constitute a meaningful learning experience for students? How many learners can use various technologies at the same time in a beneficial way? Is tracking occurring in how students are permitted to use various technologies? What constitutes teacher "use"?

Effective Instructional Practices

Currently the most common uses of technologies in schools reflect educational philosophies of instruction that view students as recipients of information dispensed by the teacher (or by the technology) and the acquisition of specific skills and knowledge. **However, many technology experts feel that the real potential of technology lies in its capacity to support pedagogical approaches that encourage students to become active participants in their own learning and to acquire critical thinking skills and more complex understandings**.

The potential for more than an electronic blackboard is one of the most compelling reasons for pursuing educational technology (see chapter 2). Right now, however, a gulf exists between the ambitions of technology experts and software developers and the practice of teachers in classrooms. Helping teachers use technology to facilitate different educational philosophies and teaching practices will require substantial change in curriculum, instructional methods, and teacher understanding.

In addition, further study is needed about the quality and relative effectiveness of various instructional uses of technologies and their applications. How effective are instructional computer games in helping students acquire specific skills and knowledge? What is the effectiveness of various kinds of video viewing experiences? How effective is browsing of digital libraries as a research tool? What elements make for a quality multimedia program? What is the most effective use of distance-learning technologies? For example, distance learning can vary greatly in quality and instructional philosophy, from teacher lectures transmitted by satellite, to more interactive learning sessions where students can conduct experiments with the distant teacher looking on or exchange observations and data in real time.

Finally, OTA finds that access to any technology in a school is just a starting point. The next chapter will explore the barriers teachers face as they try to use technology, as well as some implementation models and lessons from places actively attempting to overcome these barriers. As the next chapter suggests, to use technologies effectively, teachers and administrators must have a vision of how they can best be deployed; they need the appropriate hardware, software, and training to pursue these goals and applications, and continuing support to overcome the obstacles presented in adopting technology for instruction or teacher support.

Helping Teachers Learn About and Use Technology Resources 4

SUMMARY OF KEY FINDINGS

- Most teachers have not had suitable training to prepare them to use technology in their teaching. A majority of teachers report feeling inadequately trained to use technology resources, particularly computer-based technologies. Although many teachers see the value of *students* learning about computers and other technologies, some are not aware of the resources technology can offer them as professionals in carrying out the many aspects of their job.
- In a majority of schools, there is no onsite support person officially assigned to coordinate or facilitate the use of technologies. Even in schools where a technology coordinator exists, most of the time is spent supervising students, or selecting and maintaining software and equipment. Very little time goes directly to training or helping teachers use technologies.
- To use technology effectively, teachers need more than just training about how to work the machines and technical support. To achieve sustained use of technology, teachers need hands-on learning, time to experiment, easy access to equipment, and ready access to support personnel who can help them understand how to use technology well in their teaching practice and curriculum.
- Schools and school districts are using a number of different approaches for training teachers and implementing technology. These include developing "technology-rich" model schools; training a cadre of teachers who train and help their colleagues; providing expert resource people; giving every teacher a computer; training administrators alongside teachers; and establishing teacher resource centers. Data do not confirm that any one strategy is more effective than another; often they work in

combination. Districts may be well advised to use multiple training and support strategies tailored to the educational goals of the local site.

- Lessons from experienced implementation sites suggest that those who wish to invest in technology should plan to invest substantially in human resources. Currently most funds for technology are spent on hardware and software. Increasingly experienced technology-using sites advocate larger allocations for training and support.
- Support for technology use from the principal and other administrators, from parents and the community, and from colleagues can create a climate that encourages innovation and sustained use.
- Schools should avoid acquiring technology for technology's sake. Developing a technology plan—thinking through the goals for technology use at the local site and involving teachers in the planning process—is an important step in ensuring that the technology will be used by those it is intended to support. Many districts have found that it works best to start with small focused efforts, which can engender lessons, success, and experience before committing to more large-scale programs.
- Although sites have made significant progress in helping teachers learn to use generic technology tools such as word processing, databases, and desktop publishing, many still struggle with how to integrate technology into the curriculum. Curriculum integration is central if technology is to become a truly effective educational resource, yet true integration is a difficult, time-consuming, and resource-intensive endeavor. Research funding is needed to help explore and develop technology tools best suited for specific curriculum areas, especially disciplines other than science and math.

INTRODUCTION

As discussed in chapter 3, most schools and teachers today have at least some access to multiple kinds of video and computer-based technologies.[1] Yet much of this technology is not being used to its potential and most classroom environments are still not significantly influenced by technologies.

In contrast to chapter 2, which provided examples of promising uses to which teachers are putting new technologies, the first part of this chapter examines why teachers do not use technologies more and factors that affect how technology comes to be used in schools. This section draws on published surveys of technology use among teachers, the research literature on technology use, site visits made by Office of Technology Assessment staff to schools and districts throughout the country, a contracted series of interviews with and observations of teachers,[2] and conversations with hundreds of teachers and administrators at conferences and meetings and over electronic mail.

The chapter then describes some approaches schools have used to overcome barriers and implement educational technology more widely. Finally, drawing on places where technology has been a priority, the chapter suggests lessons learned about fostering technology implementation. In addition to the sources listed above, these sections draw on the research literature on educational and technological innovation, studies and evaluation reports from technology implementation projects, and a series of case studies contracted by OTA.[3]

FACTORS THAT INFLUENCE TECHNOLOGY USE BY TEACHERS

Why don't teachers make wider use of instructional technologies? What is the experience of teachers as they encounter new technologies in their schools? This section first provides a general

[1] Most teachers do not yet have access to or experience with telecommunications networks and related technologies. See ch. 3.

[2] Melinda A. Griffith, "Technology in Schools: Hearing from the Teachers," Office of Technology Assessment contractor report, October 1993.

[3] John R. Mergendoller et al., "Case Studies of Exemplary Approaches to Training Teachers To Use Technology," Office of Technology Assessment contractor report, September 1994.

overview of some factors that influence the extent to which teachers use technology. These include availability, time, and differences among teachers in their attitudes toward change and technology. This section then focuses on three specific areas: 1) training and understanding, 2) onsite support, and 3) systemic factors such as planning and the assessment system.

Clearly, before teachers can use the technologies they must first have access to them. As chapter 3 has suggested, the amount of computer and video technologies used for instruction in schools has grown considerably in recent years. Most teachers now have some access to these technologies. Yet as chapter 3 has also illustrated, many of these technologies are not necessarily easy for teachers to access and use as part of their daily routines. In addition, a substantial portion of the school computer inventory is made up of older, less-powerful machines. Access to telecommunications technologies is especially limited. Beyond these problems of access to machines, however, lie a number of other important barriers to more widespread use of educational technologies by teachers.

First, it is important to recognize that technology tools require time to master. Hardware and software, no matter how "user-friendly," are complicated and constantly changing. In any profession, time must be invested in learning how to use a particular piece of software to accomplish work-related goals; furthermore, keeping up with upgrades or new software requires ongoing investments of time. But teachers, in particular, are "prisoners of time:" as a national study recently underscored.[4] American schools require teachers to spend the vast majority of the school day engaged in actual instruction, which leaves little official time for planning, preparation, or learning new things. **Even accomplished technology-using teachers, who are highly motivated, rated the lack of time as among the most problematic barriers to technology use in schools.**[5]

To learn to use new technologies, teachers need time for "hands-on" exploration and collaboration with colleagues.

Furthermore, teachers are an incredibly diverse group. Some teachers express eagerness to experiment with new ideas, even at the risk of failure, while others say they have little interest, energy, or time for experimentation.[6] The great majority of teachers probably lie somewhere in between these two poles. As one educator explained, "Most schools have a bell curve distribution of teachers ranging from the aggressive, active, enthusiastic innovators to those who are counting the hours until retirement."[7] Even the most energetic and inno-

4 National Commission on Time and Learning, *Prisoners of Time* (Washington, DC: U.S. Government Printing Office, April 1994).

5 Karen Sheingold and Martha Hadley, "Accomplished Teachers: Integrating Computers into Classroom Practice, "Center for Technology in Education, New York, NY, September 1990. See ch. 2 for further information on this study.

6 See, e.g., Michael Fullan, The New Meaning of Educational Change (New York: Teachers College press, 1991).

7 David Thornburg, quoted in Electronic Learning, vol. 13, No. 6, March 1994, p.16.

vative teachers experience many competing demands to learn new things—new curriculum standards, teaching methods, behavior management techniques, assessment methods, techniques for working with special needs children, and so on (see chapter 2).

This is also true when it comes to technology. Teachers, like others who use technology, fall along a bell curve in which there is a small percentage of innovators and visionaries eager to try new things, a larger number of those who follow the lead of others, and a small group who are skeptical of change[8] (see box 4-1). Teachers vary widely in their experience with and knowledge of technology. Some teachers already have computers at home, for example, while others have never been shown how to "boot one up." Some teachers may be unclear about what technology can offer them because they have had very limited experience with technologies or little exposure to models that use technology to enrich the curriculum, deliver instruction in different ways, or improve personal productivity. Furthermore, there probably are some teachers who will actively resist or avoid learning about technology for reasons that may not be well articulated.[9] The words of one high school geometry teacher illustrate that some teachers don't want to change:

> I'm the old-fashioned type—after so many years, you build up a file on your subjects. . .For me to go into teaching computers. . .I would have to start all over. I would have to actually sit down and work everything out, and it would require a lot more work on my part to run a class the way I want it run. . . I just don't want to do it. . .Don't want to change.[10]

The kinds of pedagogical beliefs and practices a teacher holds may also influence whether he or she uses technology.[11] For example, one interview study found that "high-tech" teachers tended to hold a student-centered approach to learning (e.g., inquiry methods, collaborative learning, hands-on practices) and had used the technologies to implement this philosophy.[12] The "low-tech" teachers (those who, despite being given opportunities to use technologies, were not doing so) were more diverse in their teaching approaches. Some held student-centered educational beliefs but were reluctant to use technologies because of personal fears or inhibitions or because of problems with accessibility and scheduling of equipment. Others were described as taking more traditional approaches to teaching (e.g., following the routines of the textbook, using a lecture format); these teachers reported not using technology because they feared it would undermine their authority with students or because they felt pressed by the number of district-mandated curriculum requirements and therefore did not feel they had instructional time to give to additional activities.

No systematic data exist to tell us what constitutes the normative "technology experience" of teachers in schools today, nor whether technology is more readily used by certain kinds of teachers. However, talking to teachers—hearing their concerns and stories—can help in finding what is required to encourage more widespread use of

[8] See, e.g., Geoffrey A. Moore, *Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers* (New York, NY: Harper Business, 1991).

[9] See, e.g., Ronald G. Ragsdale, *Permissible Computing in Education* (New York: Praeger, 1988).

[10] Janet Ward Schofield, *Computers and Classroom Culture* (New York: Cambridge University Press, in press), ch. 4.

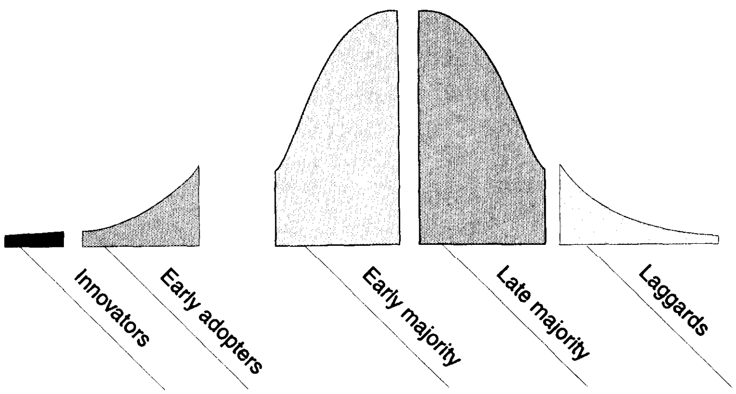
[11] See, e.g., Larry Cuban, *Teachers and Machines: The Classroom Use of Technology Since 1920* (New York: Teachers College Press, 1986); Larry Cuban, "Public School Teachers Using Machines in the Next Decade," Office of Technology Assessment contractor report, Oct. 8, 1994.

[12] "High-tech" and "low-tech" teachers were identified in each district by the district computer coordinators. Margaret Honey and Babette Moeller, *Teachers' Beliefs and Technology Integration: Different Values, Different Understandings*, Center for Technology in Education, Technical Report No. 6 (New York, NY: Bank Street College of Education, August 1990).

BOX 4-1: Acceptance of New Technologies: A Marketing Theory

This figure illustrates one market-based model of how any new technology product attracts new customers throughout its life cycle. The very small group of *innovators* pursue new technology products aggressively; they are "technologists" and make technology purchases simply for the pleasure of exploring the new technology product. *Ear/y adopters* are not technologists, but find it easy to imagine and understand the benefits of a new technology. According to this theory, there is a large "chasm" or gap between the early adopters and the next and much larger group-the *ear/y majority.* Winning the interest of the early majority is key to market success since they represent about one-third of the consumers; this groups shares some of the early adopter's ability to relate to technology, but they are also driven by a strong sense of practicality. These individuals want to see "well-established references" before investing substantially. This chasm exists, in part, because these individuals do not want to have to "debug" someone else's product—they want their technology to work properly and to be easily integrated.

The Technology Adoption Life Cycle



The *late majority* differs from the early majority mostly in that they feel less comfortable about their own ability to handle a technology product. As a result, this large group (again about one-third of the total) wants to wait until something has become an established standard. Finally, there are the *laggards* who don't want anything to do with the new technology. Generally, in marketing plans, laggards are viewed as not worth pursuing.

This model suggests that within any group of individuals, such as teachers, there will be tremendous variability in their willingness to explore and accept new technologies. Clearly there is a small group of teachers who have been active innovators and have eagerly embraced new technologies in schools. Similarly many schools have teachers who could be called "early adopters. " But today, the challenge may still lie in "crossing the chasm" and getting the next, and much larger, group of teachers sold on the usefulness and practicality of technology use for them.

SOURCE: Geoffrey A. Moore, *Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers* (New York, NY: Harper Business, 1991).

technology. In the section that follows, a number of common barriers that have been identified in the technology implementation literature will be discussed and highlighted from the teacher's perspective. In a real school setting, some, all, or none of these barriers--or other barriers-maybe present. The discussion that follows is not meant to reify these barriers or make teachers or policymakers feel that the situation is hopeless. Rather, it is intended to help alert policymakers and other readers to factors they should consider if they desire to integrate technology into teaching and learning.

Training in Technology Use and Understanding Potential Applications

Teachers' Perceptions

When asked what would help them use technology better, many teachers mention the need for more knowledge about how to use various technologies. **For some, this means operational skills, i.e., how to make the technology *work*.** In one survey, a majority of teachers said that they felt they needed training in order to adequately use a personal computer (56 percent), standard computer software (61 percent), multimedia software (62 percent), instructional videodiscs (67 percent), and online databases (72 percent). Far fewer felt the need for training in using video resources; only 7 percent of teachers said they needed training to adequately use a videocassette recorder (VCR), 9 percent for a television monitor, and 14 percent for instructional videotapes.[13]

Some teachers worry that their lack of knowledge might result in embarrassment or "feeling like a fool" in front of their students. For some teachers, this situation may be intolerable. As one teacher said:

> You can't have trouble or be messing with the machine in front of a class. It may be due to my lack of confidence, but I have to be comfortable with it if I'm going to use. . . My computer phobia, I'm actually over that. I'm not afraid of using the machine anymore, like I was, but I am afraid of how they [the students] might react.[14]

For other teachers, the greater need is understanding what the technologies can *do*. Many teachers have not had the opportunity to observe and learn about the wide range of educational uses to which technology can be put—particularly various ways it can be incorporated into different curricular areas. For example, evidence collected by OTA suggests that some non-technology-using teachers, while they endorse the importance of student access to computers and other technologies, don't see why technology should be used in **their** classrooms or what resources technology can offer **them** as they try to meet their instructional goals. One high school teacher, who did not use the computer he had been given for his class of gifted and talented students, explained, "It didn't do anything I couldn't do easier and cheaper on the blackboard."[15] In that same high school, a home economics teacher stated, "If I could see a really good use for a computer I would use one. . .but I have yet to think of anything I could do on a computer that I can't do by myself just as well."[16]

Teachers who want to use technology also may find that educating themselves enough to be able to use a particular piece of hardware or software can require considerable amounts of extra time and effort.[17] One teacher, who described himself as a technology "want-to-be," said, "It is just prohibitive time-wise to go through and read through everything, to figure out how to do everything, every time I want to do something new."[18] Furthermore, finding and integrating software into the existing curriculum can be difficult without a fairly comprehensive knowledge of available software.

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[13] National Education Association, *Status of the American Public School Teacher,* 1990-91 (Washington, DC: 1992).

[14] Keith F. Allum, "Technological Innovation in a High School Mathematics Department: A Structural and Cultural Analysis," unpublished Ph.D. dissertation, Princeton University, June 1991, p. 185.

[15] Schofield, op. cit., footnote 10, ch. 4.

[16] Ibid.

[17] Susan A. Zammit, "Factors Facilitating or Hindering the Use of Computers in Schools," *Educational Research,* vol. 34, No. 1, spring 1992, pp. 57-66; Barbara Means et al., *Using Technology To Support Education Reform (*Washington, DC: U.S. Department of Education, September 1993).

[18] Griffith, op. cit., footnote 2, p. 57.

Teachers may also need more knowledge about how to organize and effectively manage their students in technology-based environments. Some teachers have just one or two computers in a classroom, and are not sure how to use them well when only few students at a time can work on the computer. One teacher described the problem of managing a classroom of students with limited technology this way:

> It is hard enough to figure out how you are going to allow 25 students access to the computer and equal time.. .That's a huge task, and if you don't really know the benefits and the advantages and the disadvantages and all the things that whatever system you have and whatever software you have can offer, the management is just such a nightmare that you turnoff the whole thing.[19]

Even when teachers have more equipment orchestrating its use often requires knowledge about how to really teach with it or how to organize learning activities to make optimal use of the technology. For example, one French teacher had to learn how to structure her classes differently once she got technology; eventually she learned how to rotate her students through workstations that included a station with computers for drill and practice and a station with tape recorders for oral language practice:

> It was a 9th-grade class, and most of the kids. . have already worked in a class where a number of things are going on at a time, so it didn't bother them at all. It drove me crazy, but I could see it was benefiting them. I felt tom. I wanted to be with this [student]. I wanted to be with that group. It was just a question of convincing my soul that when there is noise and everybody is doing something different, learning is taking place. It's difficult for me.[20]

Teachers who want to integrate technology into their classrooms need to bear in mind the time and effort required to preview and select appropriate software materials.

Availability of Training

How much actual training or coursework about technology and its educational uses have teachers had? Available data suggest that most teachers have had very little. In one survey, less than half of the American schools reported that an introductory computer course is available (either in the district or at a local college) for their teachers.[21] This pattern was particularly pronounced among teachers in middle schools, where only 27 percent of schools reported the availability of such a course compared with 51 percent of high schools and 43 percent of elementary schools.[22]

As regards video, a different set of data found that fewer than one-fourth of teachers reported having had training in the instructional uses of video or television. Fewer than one teacher in 20 reported having received formal training over the past three years in such topics as evaluating video

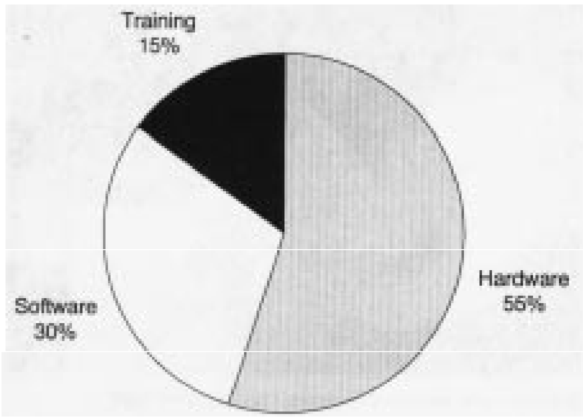
[19] Ibid., p. 54.

[20] Schofield, op. cit., footnote 10, ch. 4.

[21] Ronald E. Anderson (ed.), *Computers in American Schools 1992: An Overview,* IEA Computers in Education Study, (Minneapolis: MN, 1993), pp. 52-53.

[22] Ibid.

FIGURE 4-1: District Computer Budgets: Estimated Allocations, 1992-93



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-72 Mar/ret* (Shelton, CT: 1993), p. 11.

programming or curriculum coordination using instructional television (ITV) materials.[23] As noted above, however, this is an area where teachers feel more comfortable, and less in need of training.

Data on expenditures for educational technology indicate that far more resources have been allocated to hardware and software than to training or technical support. For example, in 1992-93, a national survey asked district technology coordinators to estimate how much of their total district computer budgets fell into each of these three categories. This survey found that approximately 55 percent of all technology spending goes to hardware, while software spending accounts for another 30 percent (see figure 4-l). Training accounted for only 15 percent. Noting that a higher portion of technology budgets is now devoted to software, the authors suggest:

> At one point in time, districts expected that teachers would create software and budgeted no dollars toward software purchasing. That has changed dramatically over the past 10 years. If any problem remains, it is found in the percentage of overall budgets devoted to computer training.[24]

These national patterns are reflected in an evaluation study of a major Educational Technology Initiative in Utah that provided schools across the state with money for technology. In the third year of the initiative (1992-93), the average Utah elementary school received $15,365 and spent 68 percent on hardware, 20 percent on software, 6 percent on repairs, and 6 percent on training. With its budget of $31,369, the average Utah secondary school allocated 75 percent to hardware, 15 percent to software, 6 percent to repairs, and 4 percent to training.[25] Data from the evaluation indicated that inservice training, though limited, had an important effect-teachers who received inservice training were more likely to use computer technology than teachers who did not receive training. Furthermore, teachers receiving training were more likely to use computers to stimulate higher-order thinking and creativity. Overall, however, the evaluators of the Utah project concluded that the current allocation of funding to inservice training was not sufficient to realize the potential of the state's considerable investment in hardware.[26]

As states such as Utah gain more experience with technology implementation, more are be-

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[23] Andrew L. Russell and Thomas R. Curtin, *Study of School Uses of Television and Video: 1990-91 School Year* (Arlington, VA: Corporation for Public Broadcasting, February 1993).

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

[25] John R. Mergendoller et al., *The Utah Educational Technology Initiative: Evaluation Update* (Novato, CA: Beryl Buck Institute for Education, January 1994), p. 11.

26 John R. Mergendoller et al., *Instructional Utilization, Teacher Training and Implementation of Utah's Educational Technology Initiative in School Districts and Colleges* (Novato, CA: Beryl Buck Institute for Education, June 1992).

coming convinced of the importance of investing substantially in technology training, especially in the early years of the technology adoption process. For example, Florida has revised its policy toward technology training. For the 1993-94 school year, the Florida legislature allocated $55 million for educational technology and $8.65 million for educational software. The appropriation required that schools applying for these technology funds set aside at least 30 percent of the money for training.[27] The Texas Education Agency recently recommended that districts allocate a substantial portion of their technology funds for staff development, suggesting that districts just getting started allocate 30 percent of their technology funds to hardware, 30 percent to software, 30 percent to staff development, and 10 percent to maintenance.[28] While Washington State does not require inservice training in technology, the state spends about 40 percent of its $4.5 million technology budget on teacher training activities (see box 4-2).[29]

One of the barriers to increasing technology training for teachers is the many competing priorities for limited staff development time.[30] This makes scheduling technology training difficult. Districts have multiple instructional goals, approaches, and philosophies they want teachers to learn about and use. In one district, for example, where the integration of "whole language"[31] teaching into the curriculum is the current educational priority, training not directly related to this goal is discouraged because it takes time that the central administration wants teachers to use for implementation of the whole language techniques.[32]

Nature of Training

The *kind* of technology training provided is as important to teachers as the availability of training. Some teachers observe that the content of training they receive is inadequate; there seems to be a focus on basic training in the mechanics of operating the machines, with little training about integrating technology into various subjects or learning to use it as a pedagogical tool. One observational study of computer use in a high school found that:

> One of the characteristics of the training teachers were most likely to complain about was its restricted technical focus. Specifically, teachers tended to be critical of the fact that the training often focused primarily on issues such as how to operate the computer without giving them much advice or assistance with two fundamental issues. . .what software was available to assist in accomplishing their educational objectives and how to organize the class to make efficient and effective use of students' time when there were a small number of computers in the classroom.[33]

Poorly timed or piecemeal training can also be a problem. Sometimes training is provided before the hardware or software arrives or before teachers know what equipment they will be using. One teacher described her school's policy in this way:

> Technology acquisition seems to have been done very piecemeal. We acquired certain pieces of equipment. We acquired certain kinds of software, whether someone donated it or we purchased it or the librarian wanted it or the computer specialist wanted it. . .It's difficult enough to sort of initiate getting training on a certain kind of equipment and then. . .the next

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[27] "A Technology-Ready State," *Electronic Learning*, vol. 13, No. 2, October 1993, p. 58.

[28] Mergendoller et al., op. cit., footnote 3, p. 6.

[29] R. Anderson, "State Technology Activities Related to Teachers," Office of Technology Assessment contractor report, Nov. 14, 1994.

[30] See, e.g., Jonathan W. Gallishaw, "The Integration of Technology into Education: A Study of Schools in Southeastern Massachusetts," thesis submitted to the graduate school of Bridgewater State College, May 1994.

[31] *Whole language* is an approach to teaching reading in which students learn words in context rather than by phonetics.

[32] Griffith, op. cit., footnote 2, pp. 25-26.

[33] Schofield, op. cit., footnote 10, ch. 4.

BOX 4-2: Teacher Inservice Technology Training: State Requirements and Resources

A recent OTA-sponsored telephone survey and review of state literature found that states rarely mandate inservice training in technology for teachers. Only Alabama and the District of Columbia require any inservice training in computers or technology for all teachers, In Alabama, five days of general teacher training are required per year; some of these inservice days must include some training about technology, but local districts can decide how much. Alabama also requires additional training for personnel who will serve as computer assistants and computer education teachers. Alabama has several state Department of Education staff assigned to assist schools with their technology training and followup, including technical assistance at school sites. The District of Columbia's recertification process requires that each teacher complete five credit hours of technology instruction (60 hours) every five years. The District's central training center has a small staff of persons who not only assist in the technology training but work with the schools on technology problems throughout the year.

Until this year, Texas required a minimum of 20 hours of inservice training per year for all teachers, in a range of areas. A recent change in legislation now allows local districts to set their own standards, Texas funds the majority of the teacher technology training in the state through 20 regional service centers. Mississippi is developing a new state educational technology plan that is projected to include a specific requirement for inservice technology training.

While most states do not mandate technology training for teachers, some support training in other ways by "strongly" recommending training, providing offsite resources, or encouraging local districts to provide funding for training. For example, Vermont strongly recommends that districts provide training for teachers in "all forms of educational technology. " Florida established technology centers at universities and other sites to provide resources, training, and curriculum development services.

Montana has established 15 regional training centers, interconnected by a state telecommunications network, the Montana Educational Technology Network (METNET). METNET facilitates the sharing of teaching resources among the centers through bulletin board systems that feature curriculum guides, lesson plans, and cooperative learning projects.

SOURCE: Ronald E. Anderson, "State Technology Activities Related to Teachers, " Off Ice of Technology Assessment contractor report, Nov. 14, 1994.

year might come and you are faced with new equipment, something you are not really familiar with. [34]

It is also a challenge to structure training for teachers with widely varying experience with and knowledge about technology. Finding oneself in a training session that is too complicated or advanced can be especially frustrating and discouraging for the novice technology user, as a school librarian described:

I went to an all-day training session. ..1 didn't even know the basics of computers. . .At one point they were talking about a menu. I started wiping my glasses. ..1 kept cleaning my glasses looking for the word menu. Then I got upset, started running to the bathroom like a child because I don't know what is going on here. Finally I raised my hand timidly. [I said] "I don't see anything that looks like food. . ." It was overwhelming for me. ..1 was not computer literate. [35]

[34] Griffith, op. cit., footnote 2, pp. 52-53.

[35] Schofield, op. cit., footnote 10, ch. 4.

■ Onsite Support and Assistance

Teachers' Perceptions

Typically, formal training sessions in the uses and mechanics of educational technologies provide only the basic knowledge that gives teachers an impetus to further experiment. Beyond this, teachers consistently report that having a person at the school site who can help them makes all the difference in the likelihood of their going further with technology-someone who is knowledgeable about technology and can help them with questions or problems. For example, when asked what one factor would help her decide whether and how to use a computer, one teacher replied:

> If I could have a few hours one-to-one with a really competent teacher that has used it—just let me ask questions [about] what I'm afraid of about a computer, what I don't understand.[36]

The inevitable technical and logistical problems that arise with technology are one reason many teachers feel the need for onsite assistance. These include such problems as machines that won't work as promised, restricted access to locked closets filled with equipment, media carts that must be scheduled and shared among many classrooms, equipment that remains broken for weeks or even months because no one knows how to fix it and repair requests take weeks or months to process. For example, one teacher who had to coordinate computer use with others in her grade, said that she would rather not have the computer than to "scuffle around the school" looking for it. It had become a "pain," rather than an asset to the classroom.[37]

Problems with scheduling shared resources such as computers in a lab can also create frustration.[38] For example, one elementary school teacher reported that all teachers at her school are scheduled to use the computer lab twice a week for half an hour at a time. Some teachers purposefully miss the time slots: "You're not supposed to, but people do, because it is a pain." According to this teacher, the scheduled time slots are too short to accomplish anything, the lab itself is poorly organized, and "some of that stuff up there is so old. . . and there are always a couple of computers broken."[39]

CALIFORNIA MODEL TECHNOLOGY SCHOOLS PROJECT—MONTEREY

Technical support is important in schools, but teachers also need informal, onsite assistance with tasks such as setting up equipment in class or trouble-shooting problems with hardware or software.

Even experienced technology-using teachers can find themselves preoccupied with troubleshooting hardware and software problems, rather than assisting students in their learning activities. The following notes made by a researcher observing a high school lab illustrate the trials that can arise; in this case, three teachers, all fairly knowledgeable, were trying to help a half-dozen or so students who liked to use the computer lab during their lunch time:

> The students. . continue to have a lot of very nitty-gritty problems. Kathy can't get the printer going. . .She's scowling and says in an annoyed tone of voice, "Please help me." Mr. East sug-

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36 Ibid., p. 28.

37 Griffith, op. cit., footnote 2.

38 Zammit, op. cit., footnote 17.

39 Griffith, op. cit., footnote 2, p. 42

> gests several things, and after they try out four or five different approaches they finally get the paper to print out. Ms. Prentiss has been working with Sharon on word processing. . .For the last 10 minutes cries like, “I don’t believe it” and “Oh, no. Not again!” have been emanating from both of them. . .She can’t get [a second] printer to work. . .At this point Mark calls to Ms. Prentiss, “I need help. . .” Ms. Prentiss puts her head down on the desk briefly. She looks at me with what appears to be a mixture of mock and real despair and trudges over to Mark. [Later in the same period] Dan is trying to use a printer which Mr. East thought he had fixed. Dan’s essay comes out quadruple spaced. In addition, every single word is underlined. Ms. Prentiss looks at it and breaks into almost hysterical laughter. Dan looks annoyed. Ms. Prentiss says, “I’m sorry, this is just too much—too, too much!. . .” Mr. Adams and Mr. East are still working on the second malfunctioning printer. Mr. Adams says, “You know I have a trick. What I do with my [home] computer is just turn it on its side and hit it. Maybe that will work here. . .” They turn it on its side and give it a whack as one of them holds the tension on the paper feed. The machine begins to work.[40]

As the above examples suggest, a great deal of what teachers need to know about technology cannot wait for a scheduled training session. As do most individuals dealing with new technologies, teachers also need informal assistance—often with a kind of immediacy that does not lend itself to afterschool telephone calls. This kind of assistance might include help setting up equipment or trouble-shooting hardware and software problems in the classroom—the more “nuts and bolts” kind of technical support.

However, as discussed in the next section, teachers also need pedagogical support such as advice on choosing relevant software and integrating it into a specific lesson, suggestions for ways the technology can be used to meet particular curricular goals, or ideas about how to organize the whole class to use four computer workstations or a single computer with a modem. Some schools attempt to overcome these barriers by having a person onsite who has responsibility for technology coordination within the building.

Availability of Onsite Computer Support[41]

OTA finds that onsite technology support personnel for assisting teachers are limited in most schools. The percentage of schools that assign a full-time nonteaching position to coordinate teachers’ and students’ computer use did not change at all between 1989 and 1992 and remains very small. In 1992, as in 1989, only 6 percent of elementary schools and 3 percent of secondary schools employed a full-time school-level computer coordinator who did not also have teaching responsibilities. In nearly three-fifths of all schools, there was no one in the school who had any portion of their workweek officially allocated to coordinating or supervising the computer program. In about one-fifth of these schools, one person, usually a regular teacher or the school media specialist, has at least half of the job officially defined in terms of computer coordination responsibilities.

In those schools where there is a “major” computer coordinator, how do they report spending their time?[42] As a group, the “major” computer coordinators report spending an average of 38 hours per week on tasks associated with computer coordination. But working with teachers to use

[40] Schofield, op. cit., footnote 10, ch. 4.

[41] Data in this section are from the 1992 International Association for the Evaluation of Educational Achievements (IEA) Computers in Education Study as described in Henry J. Becker, “Analysis and Trends of School Use of New Information Technologies,” Office of Technology Assessment contractor report, March 1994. For further description of the IEA study and its findings, see ch. 3 and app. B.

[42] For this analysis, “major computer coordinators” includes two groups—“official computer coordinators,” those whose official job descriptions included at least half-time computer coordination duties, and those who reported spending at least 20 hours per week on the tasks of a coordinator, even though their “official” job description required less.

computers is a very small part of their job, taking up an average of only 3.6 hours per week, or less than 10 percent of their total computer coordination time.[43] Most of their coordination time is spent teaching or supervising students who are using computers in computer education classes or in other subjects. Hardware and software maintenance occupies a larger percentage of time for this group, on average, than working with teachers. **Thus, OTA finds that even schools with an onsite coordinator do not provide teachers with very much school-based assistance with computers.**

Onsite Support for Instructional Television and Video[44]

Although two-thirds of schools have a person designated as a coordinator of instructional television or video, it is very rare for this to be a full-time position. In all but 3 percent of schools surveyed in 1990-91, that person had other duties; most often he or she was the school librarian, or else was a teacher, computer coordinator, or administrator.

Whatever their other responsibilities, ITV coordinators performed a variety of support functions. As reported by the school principals, these included recording programs for teachers' later use (in 81 percent of all schools), distributing teacher guides to programs (82 percent), assisting with equipment (90 percent), training teachers to use video in their teaching (56 percent), coordinating previews and screenings (53 percent), and helping to produce instructional TV and video materials (35 percent). Mirroring the fact that video is used more in secondary schools than elementary schools, ITV coordinators at the secondary level seemed to have more varied responsibilities than those in elementary schools.

Systemic Factors Influencing Technology Use

In the last several decades, researchers have begun to understand some of the processes involved in bringing about change in schools. Effective implementation of new practices or innovations in schools is influenced by many factors; these determine the extent to which new educational practices are adopted and maintained over time. Schools are organizations with many different players and constituencies. Some school cultures promote and encourage innovation, others do not. Teachers are only one part of this complex system that includes district administrators, principals, parents, students, local communities, and governmental agencies.[45]

Some educators think that training and onsite assistance are the primary ingredients necessary to facilitate widespread technology use among teachers. **While these ingredients are important, OTA finds they are not sufficient to assure that technology will be explored and used by the majority of teachers in a school or district.** Other factors that affect whether teachers use technology resources include policies that encourage teacher experimentation and collaboration, the presence of incentives for teacher use of technology, administrative leadership about technology, and public understanding and endorsement of the importance of technology as a learning and teaching tool. Two of the most critical among these are:

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[43] The "official" computer coordinators (that is, those with job definitions where computer coordination responsibilities constitute at least one-half of their job) spend somewhat more time in teacher training, but even they average only five hours per week in that activity.

[44] Data in this section are drawn from Andrew L. Russell and Thomas R. Curtin, "Study of School Uses of Television and Video: 1990-91 School Year," Corporation for Public Broadcasting, February 1993, as described in Henry J. Becker, Office of Technology Assessment contractor report, March 1994. For further description of the CPB survey and its findings, see ch. 3 and app. B.

[45] See, e.g., Michael G. Fullan, op. cit., footnote 6; William A. Firestone and H. Dickson Corbett, "Planned Organizational Change," in Norman J. Boyan (ed.), *Handbook of Research on Educational Administration* (New York: Longman, 1988); David K. Cohen, "Educational Technology and School Organization," in Raymond S. Nickerson and Philip P. Zodhiates, *Technology in Education: Look Toward 2020* (Hillsdale, NJ: Lawrence Erlbaum, 1988).

- having a vision and plan for using technology to meet instructional and professional goals, and
- evaluation and assessment policies that encourage technology use.

Clarity of Goals: Articulating an Educational Rationale for Technology Use

As explained in chapter 2, teachers who are experienced technology users can cite many reasons for using technology in their classrooms. Less experienced users, however, sometimes give rather vague rationales for adopting technology—for example, "because students need to be exposed to technology; it's the future"—reasons that do not offer a vision of how technology might be used or a clear directive as to what a teacher might need to do differently.

It is not only teachers that may lack a clear understanding of what technology can offer them, however. Responding to external pressures to "modernize," some schools and districts have acquired technology without a clear goal or educational rationale for its use.[46] For example, a computer lab might symbolize to parents and the public that a school is well-equipped to prepare children for the world of the future, even if the computers are never turned on. As one teacher said:

> [Having a computer lab is] something you can brag about to parents. . .We're in direct competition with private schools and Mr. Miller, the vice-principals, and the counselors romance the parents at the beginning of 9th grade. "You sure want to send your students here. . .Let me show you what's going on. . ." They [visit] the room downstairs showing them the marvelous new machines. . .which many private schools simply cannot afford.[47]

Furthermore, many school systems have not begun to explore the ways that technology can help them function better or differently as institutions and workplaces. **Few teachers have been encouraged to view new technologies as professional tools that can help them do their jobs better, more efficiently, or in new ways.** For many teachers, the technology that has most revolutionized their working life has been the copying machine; not only has the drudgery of the ditto machine and preparing masters been eliminated, but copying substantially broadens the range of materials a teacher can easily make available to students. Yet, some teachers report that access to and use of copying machines is restricted or cumbersome in their school buildings—for example, there may be long lines at machines during precious times when teachers are not in charge of their students or budgetary restrictions on the amount of paper teachers are allowed to use. When so many schools do not encourage teachers to use even the most basic labor-saving tools, it is not surprising to find that teachers are not supported in using more advanced technologies.

Compatible Assessment and Evaluation Systems

Ultimately, teachers will evaluate themselves and be evaluated by others based on the performance of their students. Teachers may be reluctant to experiment with new ways of teaching or new technological tools unless they are reasonably sure results will be reflected in improved student test scores.[48] Seldom can such an assurance be made, because **traditional standardized tests may not**

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[46] Means et al., op. cit., footnote 17.

[47] Janet W. Schofield and David Verban, "Barriers and Incentives to Computer Usage in Teaching," Technical Report No. 1, Learning Research and Development Center, September 1988, pp. 30-31.

[48] U.S. Congress, Office of Technology Assessment, *Testing in American Schools: Asking the Right Questions*, OTA-SET-519 (Washington, DC: U.S. Government Printing Office, February 1992).

be particularly good measures of the kinds of learning fostered by innovative uses of some technologies.[49] This problem was illustrated by the experience of a California school that purchased computers for all its students and teachers, as well as videodisc players and television production equipment. These technologies were used for challenging projects, such as producing a television news show, that required students to work together and engage in planning and solving problems.

When test scores on the Iowa Test of Basic Skills for the first year of this project failed to show any increases, disillusionment set in. The computers were removed from students' desks or even sold and a new school board, stressing a "back-to-basics" approach, was selected. All this happened in spite of the fact that the new approach had hardly been in place long enough to reasonably be expected to show a strong impact and that the Iowa tests are not an appropriate measure of the ability to work cooperatively or to plan complex projects.[50]

The evaluation and assessment system by which teachers are judged can be either an incentive or disincentive for technology use by teachers. When decisions regarding promotions or tenure take technology use and expertise into account, teachers are encouraged to experiment and work in this area. Furthermore, if teachers are expected to use technology as a tool in their own development, this sends strong signals to the profession. For example, teachers seeking national "Master Teacher" certification from the National Board of Professional Teaching Standards must fulfill a number of requirements to apply for the certification, including using technology to videotape their own classroom instruction and going to an assessment center to evaluate other teachers' videotapes of instructional practices.[51]

High school teachers develop their own projects as part of a TERC LabNet workshop, where they learn how to implement project-based investigations in their classrooms.

However, evaluating teachers on how often or how well they use technology in their teaching can have drawbacks, especially if, for example, the principal is not well versed in the various ways teachers can use technology effectively. Moreover, teachers may feel it is unfair to evaluate them if they have not received training and support in technology use. For example, one teacher who shared a computer among three classrooms admitted to her principal during her end-of-the-year evaluation that she did not use the computer much. She cited the logistical struggles associated

49 Means, op. cit., footnote 17; Joan L. Herman "Evaluating the Effects of Technology in School Reform" in B. Means (ed.), *Technology and Education Reform: The Reality Behind The Promise (San* Francisco: Jossey-Bass, 1994).

50 Means, op. cit., footnmote 17, p. 88.

51 Lynda Richardson, "First 81 Teachers Qualify for National Certification," The New York Times, Jan. 6, 1995, pp. **A-1, 16.**

with sharing the computer and the problems stemming from a lack of any computer experience or training. This teacher was marked down on her evaluation form for not using the computer, and her overall rating was lowered from "outstanding" to "good." The teacher felt quite angry about this, stating, "If she wants me to use it, then she needs to train me and she needs to have a computer available in my room."[52]

APPROACHES TO ENHANCE TECHNOLOGY IMPLEMENTATION

Overview

There are many schools that have thriving technology efforts, and many teachers who are using technology adeptly. The experiences of these places and people offer examples of strategies, pitfalls, and lessons for others that are beginning the process of integrating technology into teaching and learning.

Through case studies, a workshop, site visits, and literature reviews, OTA has examined the experience of schools, districts, and states where the adoption of technology has been made a priority.[53] Many of these places were "early adopters" and have several years of experience with the process of technology diffusion. How have they gone about infusing technology into classrooms? What resources, such as training, onsite support, planning, and more, have these places provided teachers to help them learn about technology and understand how it might help them meet their educational goals? What incentives have these sites offered teachers to enlist their interest, enthusiasm, and commitment? What other conditions are necessary to assure that technology is used effectively?

Schools and districts have undertaken different strategies to get technologies used more widely in their educational programs. These approaches share certain characteristics and they are not mutually exclusive; most schools combine more than one approach. The choice of approach will vary depending on the educational goals a site hopes to achieve with its technology and existing technological and human resources at the site. There are not a great deal of independent data on the effectiveness of these different strategies or which ones work best for different goals or in various kinds of schools. In describing these strategies, OTA offers examples of approaches that districts and schools say have worked for them.

Behind each technology implementation strategy lies a set of decisions about how best to allocate scarce technology resources. Each place has made decisions about how to invest in and distribute hardware and software—not only which technology to buy, but whether to concentrate re-

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[52] Griffith, op. cit., footnote 2, p. 60.

[53] In addition to the works directly cited, the next two sections also draw on the following: Arkansas Department of Education, *IMPAC Phase I Research and Phase II Programs: Instructional Microcomputer Project for Arkansas Classrooms* (Little Rock, AK: 1992); California Department of Education, *Building the Future: K-12 Network Technology Planning Guide* (Sacramento, CA: 1994); Central Kitsap School District, *Strategy 2020: Creating a Culture for Change* (Silverdale, WA: 1991); Chapel Hill-Carrboro City Schools, *Moving Ahead with a Vision of Instructional Technology Use* (Chapel Hill, NC: spring 1991); J.D. Ellis, "Teacher Development in Advanced Educational Technology," *Journal of Science Education and Technology*, vol. 1, No. 1, 1992, pp. 49-65; M. Fullan, M.B. Miles, and S.E. Anderson, *Strategies for Implementing Microcomputers in Schools: The Ontario Case* (Toronto: Ministry of Education of Ontario, 1988); D.S. Hurst, "Teaching Technology to Teachers," *Educational Leadership*, vol. 51, No. 7, April 1994; S. Milton et al., *Microcomputers and Other Educational Technology in the Florida Public Schools: Impact, Access, Implementation and Policy Issues* (Tallahassee, FL: Center for Policy Studies in Education, June 1989); S.E. Persky, "What Contributes to Teacher Development in Technology?" *Educational Technology*, vol. 30, No. 4, 1990, pp. 34-38; D. Paul, "An Integration/Inservice Model That Works," *T.H.E. Journal*, vol. 21, No. 9, April 1994, pp. 60-62; J.D. Russell, D. Sorge, and D. Brickner, "Improving Technology Implementation in Grades 5-12 with the ASSURE Model," *T.H.E. Journal*, vol. 21, No. 9, April 1994, pp. 66-70; J.H. Sandholtz, C. Ringstaff, and D.C. Dwyer, *Teaching in High-Tech Environments: Classroom Management Revisited, First-Fourth Year Findings*, Apple Classrooms of Tomorrow Report #10 (Cupertino, CA: Apple Computer, Inc., 1990); L. Schrum, "Tales from the Trenches: Educators' Perspective on Technology Implementation," *Journal of Technology and Teacher Education*, vol. 1, No. 4, 1993, pp. 409-421; P.A. Sturdivant, "Technology Training. . . Some Lessons Can Be Learned," *Educational Technology*, vol. 29, No. 3, 1989, pp. 31-35.

sources to make some sites "technology rich" or spread the technology more thinly across many more sites. For example, some states and districts have created ***model technology schools,*** described more fully below, choosing to invest heavily in a limited number of "technology-rich" sites. Even within a building, there can be different models of implementation: distributing technology resources evenly among classes, as opposed to placing all the technology in a lab or other central location or targeting placement in certain classrooms, grades, or curricular departments.

Schools and districts must also determine how to allocate human resource investments to assure that the technology will be used effectively in school buildings. Most of the strategies described below make significant investments in three elements of teacher support: appropriate and timely training; expertise to support and help teachers; and time for teachers to learn, "mess around" with technology, and work with colleagues. Some sites have chosen to develop a few "master teachers" at a site who are then responsible for teaching and training their colleagues, referred to as the ***"train-the-trainers"*** strategy. Other sites choose to invest more in providing an ***onsite expert,*** such as technology coordinator, who can support teachers and keep the school moving forward on incorporating new technologies. Still others choose to distribute the expertise by providing a critical mass of teachers at one site with technology tools and opportunities to learn, experiment, and adapt the technology to their own instructional needs. Additionally, ***giving every teacher a computer,*** training ***school and district administrators*** and establishing ***technology resource centers are*** implementation strategies, often used in combination with these other approaches. Each of these strategies is described in the section below.

■ Training the Trainers

A common strategy used to train teachers in many different topic areas is the "train-the-trainers" approach. In this model, selected teachers—those who are most enthusiastic and motivated to learn about a particular topic—are given intensive training. These teachers return to their buildings where they demonstrate and provide onsite training in the new techniques to other teachers. Teacher-trainers can share new knowledge with other teachers in any number of ways, including one-on-one peer tutoring or school-sponsored workshops on release days or in the summer. An advantage of this model is that teacher-trainers can continue to be available to other staff after the formal training has ended.

In the "train-the-trainers" model, teachers are selected for extensive technology training in specific applications so they can then return to their schools and train other teachers to implement those technologies.

This train-the-trainers model has been used to support school improvement and change for a variety of curricular and pedagogical goals in the past, and has also been adopted in some places to facilitate the integration of technology into classrooms. For example, in 1984-85 the Jefferson County (Kentucky) School District launched a major four-year plan, called the New Kid in School Project.[54] A 32-unit networked computer lab was installed in each of the district's 87 elementary schools and five teachers from each school were chosen to participate in a 60-hour training program at a central district site. These

[54] Mergendoller et al., op. cit., footnote 3.

teachers were then expected to train other teachers in their schools. The district offered participating teachers release time, stipends, and inservice credit for their training activities. Jefferson County used the same training approach when it implemented major technology initiatives in its middle and high schools. An independent evaluation of the New Kid in School Project, six years after its inception, concluded that the trained teachers had emerged as instructional leaders in their schools and took key roles in managing and guiding technology use.

The idea of training more than one person from a site seemed to be a key ingredient for the project's success. As one superintendent said, "The change process follows an old notion, that two people in a building can support each other and encourage the change to take hold."[55] However, training teachers in groups is not the only factor required for success.

Another factor critical to the success of many train-the-trainers projects is the availability of support and resources for the teacher-trainers once they return to their buildings. If these trained teachers are expected to share their knowledge with colleagues, they must be given time and administrative support. Furthermore, research suggests that there are personal characteristics that affect success; effective onsite technology leaders need interpersonal and organizational skills, as well as technical knowledge, in order to interest and motivate colleagues less inclined toward using new technology.[56]

An extension of the basic train-the-trainers model is being used at Webster Elementary School, a model technology school in St. Augustine, Florida. When their technology program began in 1989, the school held training sessions for all staff two afternoons a week, from 2:45 p.m. to 3:30 p.m., as part of the normal workday. As teachers began to feel comfortable with the technology and show enthusiasm, planners offered them the opportunity to become an expert in a particular piece of hardware or software. Those who were interested were given extra time to learn about the technology, more one-on-one training, and opportunities to attend technology conferences. A central list identifying these "experts" was posted in the building, and when other teachers had problems with a particular piece of hardware or software, they could consult the resident expert. According to the principal, teachers have developed pride in their new skills and have become quite self-sufficient. Technology use within the building no longer depends on outside facilitators or a single onsite expert. The principal notes with pride, "Our teacher experts do the training."[57]

Providing Appropriate Technology Resource Personnel

Several models have been used to supply the continuing specialized technology support that teachers find so valuable. These include providing temporary onsite support from commercial vendors or the school or district, or continuing support provided onsite by the school or the district.

At the beginning of a technology initiative, when a school is implementing a new technology plan or making a significant investment in hardware, bringing in a facilitator or resource person from outside of the school may be an important component of that plan. Research on implementa-

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55 Ibid., pp. 7.4.

56 For example, see Neal B. Strudler, "The Role of School-Based Technology Coordinators as Change Agents in Elementary School Programs: A Follow-Up Study," paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA, Apr. 5, 1994; Matthew B. Miles, E.R. Saxl, and A. Lieberman, "What Skills Do Educational 'Change Agents' Need? An Empirical View," *Curriculum Inquiry*, vo1. 8, No. 2, 1988, pp. 157-193.

57 Cathy Hutchins and Roger Coffee, "Teacher Experts: Empowering Staff Through Technology," paper presented at the meeting of the National Association of Elementary Principals, Orlando, FL, Mar. 8, 1994, p. 2.

tion of innovations in schools has consistently shown that onsite assistance contributes to effective implementation of new ideas.[58] For example, if a commercial vendor is supplying a large amount of software and hardware to a site, its package will often include a resource person, employed by the vendor, who spends a designated amount of time at the site training teachers and helping to "work out the glitches" with the technology. Alternatively the district or school may commit funds for a district employee or teacher at the school to facilitate the technology implementation for an initial year or two. Often this strategy assumes that the facilitators will "work themselves out of a job" after the initial implementation phase.

Some evidence suggests, however, that it may be difficult for onsite technology facilitators to phase themselves out completely. A researcher who visited three Oregon schools to observe the computer programs at two different points in time, seven years apart reported:

> During the initial study, all of the [computer] coordinators projected that they would work themselves out of their jobs in anywhere from two to five years. Implicit in this goal was the idea that as teachers became comfortable with computers and various software programs, they would eventually use them in their teaching and no longer rely upon the help of a coordinator. While this is a laudable goal to work toward, in retrospect, it underestimated complexity of educational change with technology and the amount of sustained effort that it would require of teachers. . .
>
> Three factors. . .contributed to the difficulty that coordinators found as they attempted to "work themselves out of their jobs": the rapid pace of technological change as it pertains to schools, the concerns of teachers that appear to affect their adoption of technology-based innovations, and the need for coordinating the "nuts and bolts" of educational computing.[59]

Regarding the ongoing concerns of teachers, the researcher wrote:

> When will technology become a high enough priority for a majority of teachers so that they pursue it as a regular part of their professional responsibilities? Data gathered indicate that we are still in an awkward transition period in which the benefits of teaching and learning with technology do not necessarily outweigh the costs. While teachers are increasingly citing the benefits that students derive from computer use, they must weigh the costs in terms of their time and the difficulties of managing to find appropriate software and then get adequate computer access for their students. It follows that as the quantity and quality of technology-based applications increase in the schools, more teachers will make technology a high priority. Meanwhile, the support provided by an effective coordinator serves to "tip the scales" for teachers weighing the costs and benefits of technology use.[60]

Jefferson County (Kentucky) provides an example of a districtwide attempt to provide a centralized resource pool of experts who advise and train teachers.[61] This very large urban district (96,000 students, 5,000 teachers, 153 schools) has been expanding and refining a major technology initiative begun in 1984. The District's Computer Education Support Unit, now staffed by 22 people, has primary responsibility for countywide technology training and support. In addition, the support unit has many other responsibilities, including helping schools determine their technology needs, integrating technology into the cur-

[58] Firestone and Corbett, op. cit., footnote 45.

[59] Strudler, op. cit., footnote 56, p. 18.

[60] Ibid., p. 19.

[61] Mergendoller et al., op. cit., footnote 3.

riculum, and overseeing implementation of the state technology guidelines. To provide technical support, the support unit maintains a "help desk" that any county public school employee can call with a question; the help desk receives 20 to 30 questions a day. Support unit staff have prepared 50 independent inservice units on topics that range from basic computer operation, to software selection and use, to integrating video into instruction. The unit has several training rooms set up with appropriate equipment, where inservice workshops for teachers are held. Twelve Computer Inservice Teachers are employed by the support unit to provide direct support to teachers and schools (see box 4-3). This is a coveted position; last year the unit received 60 applications for two positions. In 1993, the support unit cost approximately $916,000 for staff operation—a tiny fraction (0.2 percent) of the district's $500 million budget.[62]

Model Technology Schools and Classrooms

A number of states and districts have set up model technology schools, that is, regular schools in which a special emphasis is placed on developing student skills with and through the use of technology. By creating technology-rich environments and enlisting the involvement of those teachers and administrators who are most enthusiastic, model technology sites can "pave the way" for other schools to follow and can yield lessons to guide later technology investments. These sites can also serve as living laboratories that others can visit and learn from.

Monterey Model Technology Schools (MMTS) Project is one such example—a partnership between the Monterey Peninsula Unified School District and the California Department of Education.[63] The MMTS project represents one of six projects funded by the California Department of Education "to develop and validate a wide range of technology-based instructional and administrative programs, practices and planning procedures to be disseminated to other schools throughout California."[64] Although there are 24 schools in the Monterey Peninsula Unified School District, only four (two elementary, one middle, and one high school) are Model Technology Schools. The four schools were selected not on the basis of their readiness to adopt technology, but on two other criteria—schools had to be located in a community where the demographics of the student body mirrored the state as a whole, and the schools participating had to provide a continuum (i.e., the elementary schools fed into a participating middle school and then the participating high school).

The project was funded by the state, and all teachers in the participating schools—whose interest in and familiarity with technology varied greatly—were asked to commit themselves to the project.[65] It was recognized that teachers embrace instructional technology use at different rates. By bringing together the technologically naive and fearful with the proficient and adventurous, it is possible to build a climate of mutual support and a culture of school technology use. It was anticipated that this process was more likely to be ex-

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[62] Overall, Jefferson County Schools spent about 1 percent of the yearly budget on technology purchases, installation, upkeep, and support. Ibid.

[63] Ibid.

[64] J.D. Cradler et al., *Monterey Model Technology Schools: Cumulative Research and Evaluation Report,* 1987-1992 (as cited in Mergendoller et al., op. cit., footnote 3, p. 6.4).

[65] Those who did not want to work in a school endorsing substantial technology use were given the opportunity to transfer to other schools in the district, but none did. Some teachers chose not to participate during the first year of the project; some of these teachers and some others later transferred to other schools or retired.

BOX 4-3: Computer Inservice Teachers in Jefferson County

In Jefferson County, Kentucky, 12 computer inservice teachers (CITs) work directly with the teachers in the districts' 153 schools. Each CIT is currently assigned to 16 schools, a challenging load in the opinion of many. Typical duties include:

- talking on the phone or in person with school technology coordinators to schedule teacher training workshops or ensure that the pace of the school's technology spending is on track;
- trouble-shooting software and hardware problems;
- ordering equipment for schools through the district's procurement service;
- working with individual teachers to integrate technology into their instruction;
- working with the school technology committee and the technology coordinator to review school technology needs and prepare a technology plan;
- presenting three-hour afterschool workshops for the teachers in their assigned schools; and
- presenting all-day workshops on a particular computer topic such as Hypercard or using spreadsheets in history classes.

With so many different demands, CITs have found that they must rely on each other for expertise and support. CITs carry a Powerbook with an internal modem. This allows them to access the Computer Support Unit e-mail system, and leave and receive messages for each other or their supervisors at any time. Although the expertise of each CIT is somewhat different, they share a core knowledge about feasible ways to integrate technology into instruction. As one CIT put it:

> We start with curriculum first, We ask teachers, "What do you want to do?" Then we look to see how technology can accomplish it. But it always comes back to the *curriculum first.* Do you really need the technology, or have you just been sold a line?

The CITs respect the teachers they work with and appreciate the human dimension to technology infusion. As one teacher told us:

> Computer Resource people are not insulting when they talk with you. And the attention and support they give you is just incredible. They don't tell you what to do, they invite you to do it. They just put this little bug in your ear and walk away. "You know, " they say, "You really should try telecommunications. Take a look at this World Classroom program...." and then you think, "Hmmm. This does look interesting. ." The Computer Inservice Teachers set the stage and the environment, and then I drive myself to learn it.

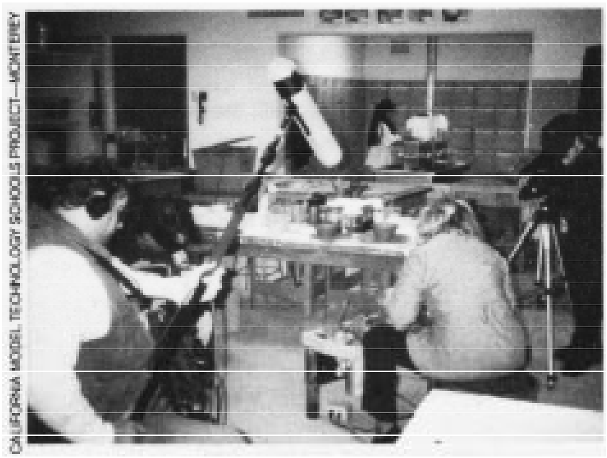
Another teacher talked about the informal process of technology infusion that occurs within a school:

> First the Computer lnservice Teachers help you. And then you finally get it down and it spreads. It's exciting Other teachers see you using technology. All you got to do is show what your kids are doing to another teacher. They see that the kids are so excited and learning things and they want to do it in their class. So they learn it, and the teacher next door comes down and says, "Now Cindy's kids are using computers; I want mine to use them too. When are you going to show me how to do it?"

SOURCE: John R. Mergendoller et al , "Case Studies of Exemplary Approaches to Training Teachers to Use Technology, " Off Ice of Technology Assessment contractor report, September 1994, pp. 18-19.

portable to other schools than selecting a school where all teachers are "ready" to use technology.

Originally funded in 1987, the first five years were focused on developing technology implementation projects and training, with dissemination activities targeted for year six onward. First-year training centered on "Technology Awareness Days" focused around the subject areas of language arts, mathematics, and science, to provide a general overview of what could be accomplished with educational technology. Gradually, what began as a technology training program



At Monterey Model Technology Schools, teachers produce a video for dissemination to other schools as part of the district's teacher training.

evolved into instructional mentoring, changing the focus from broad curriculum areas and operating skills to an emphasis on targeted student outcomes and behaviors. At this point, MMTS developed the Classroom Intervention Plan (CIP), which became the centerpiece of the MMTS technology infusion model. Each teacher or teacher team develops a CIP outlining the curriculum emphasis (and its relationship to their school's planning goals and those of the California curriculum framework), the desired and measurable end results; the necessary hardware, materials, and staff development; the evaluation plan; products and procedures for dissemination; and a budget (including substitute time). In addition to hosting scheduled visits by interested teachers and administrators, the Model Technology Schools provide three types of training and dissemination activities to teachers from Monterey and other districts in California:

1. **Technology Demonstration Centers.** Teachers who are well-trained veterans of the MMTS program hold a day-long session in which they demonstrate their knowledge for a group of 2 to 12 teachers. Topics include such things as Info-Trek and Telecommunications, Logo in Mathematics Courses, Using Laptops for Process Writing, and Using Video and Camcorders across the Curriculum.
2. **Technology Training Seminars.** More extensive two-day hands-on training workshops are offered to teachers on six different technology configurations: Telecommunications, One-Computer Classroom, Laptops and Process Writing, Multimedia, Video, Instructional Television. Teams of at least two teachers from the same school must attend together to facilitate support when they return. In addition to spending considerable time on hands-on exploration of hardware and courseware, participating teachers develop an individual project to use in their own classrooms.
3. **Teacher Productions. The** MMTS teachers have produced several documents, discs, and videos showcasing the projects they have implemented in their classrooms. These are based on the CIPS described above. Selected project descriptions and productions in the MMTS products catalog are shown in box 4-4.

On a smaller scale, some schools or districts have chosen to start with model technology classrooms instead of schools. The Integrated Technology Classrooms (ITC), begun in 1987 in Bellevue, Washington, are one such example.[66] Under a pilot program in two elementary classrooms, teachers who had demonstrated enthusiasm for using computers were given a range of instructional technologies. The theory was that concentrating technology expenditures in a single classroom would demonstrate the value of technologies.

The program has been very popular and successful in drawing in other teachers. The number of ITC classrooms has grown from two in 1988 to more than 60 today. The ITC teachers, each in a different school, have worked with colleagues in their buildings to model technology use and help teach others about it.

[66] Mersendoller et al., op. cit., footnote 3.

BOX 4-4: Teacher Productions Showcasing Promising Practices

The following are examples of handbooks, software, and videos produced by Monterey Model Technology School teachers to illustrate technology activities they have used in their classrooms.

Minds in Motion

A series of learning activities for the elementary classroom using LogoWriter™ and Lego® logo kits in cooperative learning groups.

Integrating Technology into the California Writing Project

This guide stands as a roadmap for teachers who wish to enhance the writing process through the use of instructional television, video, and computer technology.

Into the Eye of the Atom

This physical science unit has been developed to assist students in visualizing and conceptualizing the structure of atoms and molecules using laser, video, and computer technology.

Database of Dietary Choice

A guide to creative uses of databases and spreadsheets in the home economics curriculum.

The Whole CAKE: Computers Assisting Kids in Education

A team of elementary teachers developed this integrated, technology-based instructional model to help students improve their oral and written expression, increase exposure to quality literature, develop good handwriting skills, and improve the quality of television viewing.

Lit Vid Kits

This model was developed as a means of creating motivating language arts experiences in a school-to-home format for elementary students. Its focus is on English language acquisition and non-English-speaking parent education. It includes reading, listening, viewing, speaking, and writing activities related to thematic units in literature and science (available in English or Spanish).

An Integrated Approach to Geometry Using Manipulative, Robotics, and Computers

This collection of classroom learning activities was developed to meet the needs of middle school students facing difficulties in mastering geometric concepts.

Echoes

This kit provides teachers with a model for developing units that intensify student interest in civics and economics and enhance cooperation in teamwork settings.

ARTT

This resource outlines planning, building and management of video libraries to enhance the instructional process in a secondary arts program.

SOURCE. California Model Technology Schools Project-Monterey, 1995.

Giving Every Teacher a Computer

Although this strategy is still quite rare and experimental, some schools and districts are giving each teacher a computer to use as a personal and professional productivity tool. As discussed in chapter 2, computers can help teachers carry out many aspects of their job, such as keeping records, updating lesson plans, and constructing tests. The rationale is that as teachers begin to see direct benefits from technology, in terms of saving time or expediting routine tasks, they will become more motivated to learn about computers. And as teachers gain confidence with and understanding of computers and related technologies in their own work, they may begin to experiment with using technologies with their students. While some training is still important in this strategy, the real learning is believed to come from giving teachers unlimited access to the technology (and potentially more time on the equipment), new motivation for learning to use it, and a community of peers who are trying to master the same tools. Because teachers do much of their planning and paper work at home, some sites allow teachers to take their computers home routinely or keep them there; others provide laptop computers they can carry back and forth.

One innovative program that uses this strategy, and is sponsored by the Indiana Department of Education, is called A Computer for Every Teacher (CET). Begun in 1990, CET made competitive grants to four small schools on the basis of proposals. Participating schools had to assure that all teachers and other professional staff in the school would participate. Every teacher in the funded schools received a computer and printer for use at home or in school, as they saw fit. The program aimed:

> . . .to improve teacher productivity and enhance teacher professionalism with the long-range goal of improving student performance. It is based on the belief that teachers are information-age professionals who should be using contemporary technology to accomplish their work. By using such technology, their personal productivity will improve and, consequently, so will their instructional efforts and impacts in the classroom.[67]

CET program grants covered training that focused on basic computer functions and software selected by each school. Training at all sites included basic elements of wordprocessing, graphics, spreadsheets, and databases; most teachers were also taught how to use a gradebook program. Participants viewed the requirement to involve all professional staff as an important component of the program; "everyone means teachers, administrators, and support staff, all working together on the same tasks of mastering computers and software."[68]

This formal, public commitment also gave leverage to the coordinators when it was time to train the school staff. While there was some reluctance—and training did not turn around every teacher—almost all teachers and administrators learned how to accomplish some basic functions on the computer. An outside evaluation of the project two years after it had been implemented in the four sites concluded that the program was highly successful in meeting its goals and helped teachers improve their productivity, enhance their sense of professionalism, and increase individual and institutional esteem.[69] (See box 2-6 in chapter 2.)

Results of another experiment in Utah, the "Lifestyle Change" Project, indicated that teachers are highly motivated by the opportunity to have a computer of their own. Recognizing the drawbacks of training teachers to use technology that is only sporadically available to them, this

[67] Saul Rockman, James Pershing, and William Ware, "Productivity, Professionalism, and Empowerment: Given a Computer for Every Teacher," report prepared for the Indiana State Department of Education, October 1992, p. 3.

[68] Ibid., p. iv.

[69] Ibid.

project put a computer in the hands of all teachers and administrators in Utah's Morgan School District. To qualify for a computer, which could be used at school or at home, teachers had to complete a comprehensive program of training, including a course introducing Macintosh hardware, a gradebook package, word processing, graphics manipulation, a program for developing classroom tests, Hypercard for software authoring, and a course on videodisc/CD-ROM. Teachers were also required to complete a portfolio of computer-generated materials such as gradesheets, worksheets, Hypercard stacks, videodisc lessons, and word-processed documents.

An outside evaluation of the Lifestyle Change Project concluded:

> The "Lifestyles" Project of the Morgan School District has succeeded in enlisting the active involvement of 84 out of 86 potential participants. From the results of a written questionnaire, a series of interviews, onsite observations, and an examination of individual assignments completed, the Project receives high marks for both involvement and attitude change. Along a number of dimensions. . . this has the earmarks of being a superior project.[70]

CALIFORNIA MODEL TECHNOLOGY SCHOOLS PROJECT—MONTEREY

Including principals in school-based technology training means they will be informed and comfortable with the technology, and more likely to provide leadership and support for school wide technology use.

Training Administrators

Research on the adoption of innovations in schools consistently points to the key role of administrative leaders in successful implementation. Involved and supportive superintendents are central to districtwide reform efforts, and principals are key to implementation within the school building?[71] **OTA has consistently found that when administrators are informed about and comfortable with technology, they become key players in leading and supporting technology integration activities in their schools.**[72] Some technology implementation efforts are building on these lessons by including principals or other key administrative staff in training opportunities offered to teachers.

One approaches to include principals in school-based teams chosen to receive intensive training in technology use. For example, the Apple Classroom of Tomorrow Teacher Development Center Project looks at the commitment of the principal when selecting teacher teams for training. Not only are principals encouraged to attend portions of the training program with the teacher team, but they also must commit to the following conditions: release time for teachers to attend project training sessions, time for teachers to meet and

70 Nick Eastmond and Inhae Kim, "An Evaluation of the Project 'A Lifestyle Change' Final Report," unpublished manuscript, Apr. 9, 1992, pp. 22-23.

71 Fullan, op. cit., footnote 6; Firestone and Corbett, op. cit., footnote 45.

72 See, U.S.Congress, Office of Technology Assessment, *Power On!: New Tools for Teaching and Learning,* OTA SET-379 (Washington DC: U.S. Government Printing Office, September 1988); *Linking for Learning: A New Course for Education,* OTA-SET-430 (Washington, DC: U.S. Government Printing Office, November 1989); Mergendoller et al., op. cit., footnote 3; Griffith, op. cit., footnote **2.**

plan each day, time for teachers to reflect on practice, and acknowledgment of the importance of their teachers' efforts to the rest of the staff.[73]

Since 1990, Indiana has sponsored a statewide training program specifically for principals. In its first two years, the Principals' Technology Leadership Training Program served almost 400 Indiana principals.[74] Over the course of a year, each principal takes four days of professional training with other principals at a central site. By scheduling sessions at different points in the year, the program built in time for principals to go back to their schools, practice what they learned, and talk to staff and better define what they needed and wanted. In the workshops, principals learned about a broad range of technology and software available for classroom and office use and had a chance for hands-on exploration of a large collection of equipment.

Participating principals have been very enthusiastic about the Technology Leadership Program. In addition to reporting that they felt more confident and credible in dealing with technology, and better able to use technology for administrative tasks, participating principals said they were more capable of creatively using capital project funds, writing grants, or justifying expenditures to school boards. After the training, many principals conducted training for their teachers; others reported that they were better equipped to think comprehensively about the technology in their schools and how best to use it. Principals rated an update session, held the following year, as very valuable, and most principals endorsed the need for some kind of ongoing "refresher programs."

Although there are no systematic data on the effects of training principals, the Apple Classroom of Tomorrow (ACOT) and Indiana examples demonstrate the feasibility and importance of enlisting principals in the diffusion of technology in schools.

Establishing Technology Resource Centers

Some states and districts have established technology resource centers where teachers can experiment with different hardware, try out software programs before buying, consult experts, and receive training. For example, Calcasieu Parish Schools in Lake Charles, Louisiana, established a district "Tech Center" that offers training on different technologies, a satellite dish to receive or record educational teleconferences, and online computer access to a library of over 100 current periodicals and other resources. The center remains open until 7 p.m., three nights a week, and is open on Saturday mornings.[75]

Texas supports 20 Regional Education Service Centers (RESC) that provide a wide range of services to school districts in their region on a variety of educational issues, including technology.[76] Although RESCs receive operating funds from many different budgets, the Texas Education Agency distributes $6 million a year to RESCs specifically to support technology initiatives. Each RESC has considerable flexibility in the way funds are used but is expected to carry out the following activities, at a minimum: 1) maintaining a Technology Preview Center where district personnel can "investigate and select technologies appropriate to meet local needs;" 2) helping districts train teachers, administrators and other staff in technology-related topics; 3) training first-year

[73] Cathy Ringstaff, Keith Yocam, and David C. Dwyer, "ACOT Teacher Development Center Annual Progress Report: Year One," unpublished manuscript, n.d.

[74] S. Rockman and K.R. Sloan, "A Program That Works: Indiana's Principals' Technology Leadership Training Program," report prepared for the Indiana State Department of Education, San Francisco, CA, June 1993.

[75] As described in Metropolitan Education Research Consortium (MERC) Research Brief #8, "Developing Exemplary Technology-Using Teachers," May 1994, *MERC's Work,* vol. I, No. 2, 1994.

[76] Mergendoller et al., op. cit., footnote 3.

teachers in technology use; and 4) disseminating material from the Texas Center for Educational Technology. (See box 5-3 in chapter 5.)

A typical RESC has at least one training room equipped with computers, all with connections to TENET, the statewide computer network for teachers. Some of the computers also have network connections to the Internet. (See box 3-4 in chapter 3.) This room or an adjacent room generally serves as a Preview Center. RESCs purchase software and hardware for the center, and several software publishers provide copies of their products to each center at no charge. Most RESCs offer a continuous series of workshops, seminars, and training sessions on various topics related to technology use in schools; teachers are the primary users of these staff development activities. Larger RESCs have as many as five or six staff who work full time in the technology area.

LESSONS ABOUT TECHNOLOGY IMPLEMENTATION

Based on OTA-contracted case studies and site visits, and a number of other research and evaluation studies, OTA has drawn some lessons about how to foster effective use of technology by teachers in K-12 schools. Sites that have made technology a priority, such as those described above, provide lessons about how to implement new technologies, how to make decisions about acquisition and investment in technologies, and what kinds of support can help teachers use technology effectively. Leadership necessary to infuse technology comes from many sources: the state, the district, and the individual school (see box 4-5). Ideally, all these work together to support the teacher's efforts to learn about technology and use it to meet classroom goals.

Key Issues for Investing in Technology

Access

Several factors seem to be essential for making the best use of hardware and software in schools. The first condition is **ready access** to hardware and software. Access cannot be assessed simply by looking at the numbers—how much hardware and software a school owns tells you little about its accessibility. To be accessible, technology must be readily available for teachers to use when they need it:

> . . .not simply for uses that can be predicted in advance and squeezed into a fixed time slot. For example, teachers are far more likely to use video for instruction when the choice and timing are under their control. Similarly, teachers and administrators are less likely to use telecommunications networks when they must go to a remote location to do so. Nor can students exploit the full power of word processing if they must wait for their daily or weekly scheduled time in a lab.[77]

Ready access to equipment is also a precondition for teacher training. It is extremely frustrating for teachers to learn to use technology in a workshop, then return to a classroom that does not have it. Some have experimented with postworkshop "Try and Buy" programs that supply teachers with necessary equipment for four to six weeks or so, to enable them to become more familiar with a technology before the school decides whether it wants to buy it. Schools are trying to increase teacher access by letting them take equipment home.

Access also requires keeping hardware and software in up-to-date working order. For schools to incorporate technology into their program in a meaningful, long-term way, they must recognize

[77] Jane L. David, "Realizing the Promise of Technology: A Policy Perspective," in B. Means (ed.), op. cit., footnote 49, p. 178.

BOX 4-5: State Planning for Technology: The New Jersey Experience

The State of New Jersey provides an interesting example of the planning process involved in bringing technology into K-1 2 schools, and how that process has evolved over time.

In 1986, the New Jersey Department of Education developed *Education/ Technology in New Jersey: A Plan for Action,* which outlined the department's role in helping districts develop policies, practices, and programs to increase student learning through computers and other forms of educational technology. It was recognized that changes in technology would probably necessitate a new plan within a few years. In 1991 New Jersey Commissioner of Education John Ellis initiated a process for developing a statewide long-range plan for educational technology, an idea reinforced by the Quality Education Commission of New Jersey. In February 1992, the Department of Education formed a 60-member task force composed of individuals representing school districts, higher education, business and industry, research laboratories, museums, libraries, government and community agencies, and other major educational stakeholders. The task force produced the second version of *Education/ Technology in New Jersey: A P/an for Action,* completed in 1993.

The vision outlined in the 1993 plan is a bold one: "All New Jersey students will be able to use the tools of educational technology effectively, holding in their own hands the means to shape their own destinies."[1] The outcomes envisioned in the plan include the following: student access to learning technologies, high-quality professional development and training for educators, multimedia workstations for all teachers, online access for administrators to gather and report data, school facility retrofitting to integrate technology throughout school operations, and equitable funding to each school district through a technology entitlement that provides funding on a per pupil basis each year to districts with an approved technology plan.

The overall plan has four broad "action plans" that were slated to be fully in place by 1997. These action plans are:

- ***Building Educational Leadership:*** "To establish coalitions of key stakeholders" that will build on the state's human, capital, and corporate resources and provide vision, leadership, and support to implement local technology plans.
- ***Preparing Educators for New Roles:*** "To provide educators with ongoing, accessible educational technology preservlce and inservice professional development opportunities that prepare them for new roles as facilitators of the learning process and improves instruction and learning. "
- ***Modernizing Learning Environments*** "To provide leadership with financial and legislative support to restructure the educational environment in school facilities" by constructing a voice, video, and data communication network in each school.
- ***Developing Networks and Technology Infrastructure*** "To provide vision, leadership, and support in the construction of statewide voice, video and data networks" to deliver timely resources and integrate data management among districts, other agencies, and the Department of Education. Networks will be governed by a coordinated organization with representation from public schools, libraries, vocational-technical centers, community colleges, four-year colleges or universities, government, and industry.

The second action plan, dealing with professional development, has five primary objectives:

- Establish a network for professional development with collaboration of K-12 education, higher education, and the private sector.
- Provide statewide support for ongoing, accessible staff development opportunities to integrate educational technology into Instruction.
- Provide resources to prepare educators for new roles, including the establishment of educational technology training and support centers.

[1] New Jersey Department of Education, *Educational Technology in New Jersey A Plan for Action* (Trenton, NJ April 1993), p I

BOX 4-5 (cont'd.): State Planning for Technology: The New Jersey Experience

- Collaborate with higher education institutions and classroom practitioners to develop and provide educational technology preservice opportunities.
- Prepare educators to use technology to acquire more detailed knowledge about student performance.

The implementation of the overall plan has been contingent on appropriations provided by the state legislature, Five funding recommendations were proposed for the state legislature:

- appropriate $50 per pupil for every full-time K-12 student in New Jersey public schools—roughly $60 million—and renew annually to keep the technology current;
- appropriate a one-time investment of approximately $8 million to fund development of a statewide fiber-optic telecommunications network capable of carrying voice, video, and data transmissions;
- provide an annual $1 billion appropriation to provide financial incentives, such as low-interest loans, to districts for construction and retrofitting projects to support technology infusion;
- create a "megasystem" for data management to streamline administrative tasks and increase communication between districts, agencies, and the state, at an estimated cost of $30 million over three years; and
- appropriate funds for technology modeling incentives to develop and demonstrate exemplary uses of educational technology, at a cost of $5 million the first year, $10 million the second, and $15 million the third.

The State Board of Education was encouraged to take a number of actions, including:

- requiring student performance proficiencies with the new and emerging technologies,
- requiring provisions for new and emerging technologies in new construction and retrofitting plans, and
- requiring staff training in technology be included with all technology purchases made by districts.

Recommendations were also made to the State Department of Education:

- create a clearinghouse of educational technology resources, accessible to the entire education community,
- provide technical assistance for the effective use of technology in the instructional process, and
- provide leadership in constructing and developing a statewide network and interagency data management system.

Local Education Agencies (districts) were encouraged to:

- develop and implement a multiyear technology plan;
- designate a technology coordinator for the district;
- designate funds for the purchase and maintenance of technology, and for professional development in technology use; and
- develop, approve, and implement a board policy on the infusion of technology into the curriculum and school operation.

Despite the extensive planning, assignment of responsibilities and attention to detail, political realities have made it difficult to carry out the plan as envisioned. The major barriers have been fiscal constraints and changing political administrations, which has meant re-submitting proposals many times over and subsequently losing valuable time. Two years ago, budget constraints led to a reduction in the staff of the state Educational Technologies Office from 11 to two. Governor Christine Todd Whitman's austerity program has also trimmed the budgets of most state agencies considerably. Nevertheless, the Educational Technologies Office has been able to maintain its efforts on a limited budget, and this year was granted a $500,000 appropriation with which to begin implementation of the technology plan.

SOURCE: Julia Stapleton, Education Technology Coordinator, New Jersey Department of Education, *Educational Technology in New Jersey: A Plan for Action* (Trenton, NJ: New Jersey Department of Education, April 1993).

that there will be considerable costs. Technology must be repaired, upgraded, and replaced. In addition, seemingly small but ongoing costs—paper, printer ribbons, discs—have been known to cripple some technology initiatives. **Schools must not view technology as a one-time investment but must budget for maintenance, upgrading, and replacement costs.**

Instructional Vision

A second factor related to equipment that schools should consider is the suitability of particular technologies. Available technology must be *suited to the educational goals* for which it is intended. Investments should not be made in technology for its own sake, but because it facilitates or extends instruction. **This requires that a well-defined instructional vision should precede the technological one; teacher involvement in defining this vision is essential.**

Most successful districts and schools have spent considerable time and effort planning for technology infusion before purchasing and distributing equipment. Often states or districts require individual schools or classrooms to develop a technology plan. The planning process requires people to think through the reasons for the technology before they buy it. It also helps to assure that sound educational reasons guide the technology decisions, instead of technology driving the educational process. Furthermore, the planning process brings people together and requires them to consider technological and instructional priorities. Although the resulting written plan affords a useful guide, it should be seen as a starting point, subject to revision over time. Nonetheless, it is the process itself that animates individuals, focuses their attention on instructional goals and technology's role in meeting them, and supports cultural changes in technology use.

Plans should not be ironclad; they should make it possible to revise or adapt as the implementation process proceeds. Lessons can be learned, and some parts of programs can be imported or changed. Sites have learned that they need to be flexible and encourage experimentation and sharing. **They have found that they have to expect to change and update their plans as the program evolves, as teachers gain expertise, and as technologies and applications advance.**

Sustainabilty

Programs have found that it is extremely important to think about continuation of the technology program from the beginning. Although seed money can get things started, a successful program will need to think about how technology use can be built into the continuing culture of the school. Research on organizational change has suggested that for innovations to be built into the organization on a regular and permanent basis, adjustments must be made in at least five ways:

- new practices must be codified as rules;
- curriculum must be revised to accommodate the innovation;
- training programs must be established for newcomers to the district;
- evaluation procedures have to reflect the new practice; and
- project-related activities must be supported as line items in the regular district budget.[78]

Key Issues for Investing in the Human Resources

Once a site has accessible technology suited to its particular purposes, what else is needed? Perhaps the most central lesson from successful implementation sites is that those who wish to invest in technology should also plan to invest substantially in human resources. For every investment in

[78] M. Huberman and M.B. Miles, *Innovation Up Close: How School Improvement Works* (New York: Plenum, 1984); Firestone and Corbett, op. cit., footnote 45, p. 331.

hardware or software made, there should be a substantial investment in human resources, through expenditures for training, technical support, maintenance, and time to learn to use the technology.

> Life cycle cost models from business and industry support the critical role of training and support. These models suggest that hardware and software reflect approximately 30 percent of the total system cost over the technology's life cycle. Too often funding initiatives ignore the entire set of funding components and focus on hardware and software. And yet, experience has shown that only by addressing the other components, as well as the hardware and software, will the technology expenditures be successful. This is most particularly true of the staff development cost component . . . Teachers need extensive and on-going training not only in how to use technology, but how to fully integrate it into their curriculum, instruction and assessment practices.[79]

Redefining Training

Some of what teachers can do with technology can be learned on their own through experimentation and self-instruction. But there are other things that teachers can learn best by attending a workshop or watching an experienced teacher. **A good staff development program will have opportunities for both types of learning.**

"Hands-on" training with technology is more than a gimmick or motivator; it is a necessity. Teachers must have the chance to make the computer (or camera or whatever) work and gain confidence in their own competence before trying the same thing with their class. Moreover, the different types and applications of technology will require different amounts and kinds of training, support, and mentoring. For example, learning to use a telephone voice-mail system for communicating with parents and teachers is likely to require less training than learning to create multimedia


TERC, CAMBRIDGE, MA

In workshops, teachers have opportunities to explore different technologies in ways that can be transferred to the classroom.

lessons using Hypercard and a videodisc player. There is no one generic course or workshop that can effectively teach teachers all that they need to know about technology.

There is abundant evidence that "one-shot" or short duration training programs have little impact. Teachers need time to learn, plan, try things out, reflect on their successes and failures, revise, and try again. This takes time—months, if not years.

Incentives like providing release time for teachers or paying them for staff development can increase the participation of teachers in good staff development programs. But release time can be problematic. Many teachers want to minimize the amount of time they spend outside their classrooms (and find the job of preparing plans for substitutes a time-consuming task). Some sites have tried to find creative and low-cost approaches to release time, such as conducting inservice activities onsite and having a teacher from the building as instructor (see box 4-6).

Staff development is most effective when it is individualized. This means matching learning opportunities to the needs of specific teachers so they can choose what they need to know, how they

79 Michael Radlick, *A Cost Model: Implementing Technology in New York State Public Schools* (Albany, NY: New York State Education Department, November 1994), p. 11.

BOX 4-6: SuperSubs: Making It Easier To Learn About Technology

When teachers leave the classroom, they usually prepare lesson plans for the substitute teacher (sub) who will take their place. Because the regular teachers are trying to guide a stranger into the instructional routines that are second nature for them, the sub release lesson plans are often much more detailed and take more time to prepare than a regular lesson plan. In the Monterey Model Technology Schools (MMTS), this caused a problem: teachers didn't want to take the time to be trained in technology use because each time they left their class to visit other classes or attend training sessions, they had to labor over lesson plans for their substitutes, But without the training, they couldn't use the technology.

The MMTS staff sought a "turnkey" solution: a generic substitute teacher who could come into a class with a minimum of preparation required of the teacher who was to be released. Since the project was about technology, they thought it would be appropriate if the substitute provided technology-based learning experiences while their regular teacher was also becoming more proficient in technology use. Another concern was that of cost. If considerable substitute activity was to be central to the training model, the substitute service had to be cost-effective.

Thus was born the "SuperSub Service, " a strategy that enabled MMTS staff to continue to individualize the staff development assistance they provided while reducing the burden teachers experienced when preparing for a substitute. Briefly, this strategy:

- provides for weekly release time for teachers during the work day (ranging from 45 to 270 minutes);
- removes the necessity for teachers to prepare lesson plans for the substitute teacher;
- provides a technology-enhanced problem-solving, critical-thinking skill development lesson aligned with the district curriculum for each SuperSub to deliver; and
- provides the teacher with written feedback about the SuperSub's lesson as well as a followup activity.

To maintain continuity and lower the cost, the SuperSub Service is staffed by four Monterey district teachers and administrators who elected to take early retirement. All district teachers who elect to retire before the mandatory retirement age are required to contribute 30 days of work to the district each year for three years. By drawing on this network of early retirees, the MMTS Project did not exacerbate the existing difficulty district schools have in finding qualified substitute teachers, and released the funds that would have been spent on substitute teachers for other purposes.

SuperSubs are equipped with an Apple portable computer, a LCD projection device, a notebook of lesson plans and suggested followup activities, necessary supplies such as scissors and crayons, and a letter the SuperSub can use to describe what went on while the regular teacher was away. A schedule of SuperSub visit days is established at the beginning of the school year. The schedule lists both the days SuperSubs are available and the staff development activities teachers can participate in on those days.

If the demand for SuperSubs is evidence of the program's effectiveness, this approach to provide release time for teachers is an effective one. Between the second and third year of the program, use of SuperSubs doubled, while use of full-day regular substitutes and afterschool training sessions declined. Project funds originally allocated for full-day substitutes were reallocated to additional instructional materials or attendance at technology conferences. Increasingly, teachers are using the SuperSub service as an opportunity to share their skills with their school colleagues or observe how their colleagues teach their classes. Teachers appreciate that their own professional development activities can be scheduled within *the school day at a time they choose.* They also like the continuity the SuperSub service provides—the same SuperSub returns several times over the course of the year and gets to know the students and the teachers, making the substitute teacher experience a more positive one for everyone involved.

SOURCE John R Mergendoller et al , "Case Studies of Exemplary Approaches to Training Teachers to Use Technology, " Office of Technology Assessment contractor report, September 1994 wish to learn it, and the time frame in which they will learn it. This matches the "just-in-time" training models increasingly adopted by business and industry.

Followup support and coaching after the initial learning experience are essential to effective staff development. Teachers cannot "learn all" they tried at a training session, even if it extends over several weeks. When they return to the classroom, the unexpected inevitably happens. At this point, teachers need to be able to access technical assistance and support. Some sites structure courses so that they meet periodically through the year or for a month or two, rather than one or two long days. Participants can try out new skills, practice, then come back to class and discuss or refine their approaches. During teachers' initial efforts to integrate technology into the classroom, it helps a great deal to have support immediately and continuously available. Increasingly, schools are finding that electronic networks linking participants with instructors and each other provides a resource for continuing support.

Technical and Pedagogical Assistance

Because districts, schools, and teachers vary widely in their "technological readiness," most successful sites have found that they need to provide a variety of resources and supports such as those described in this chapter. Some kind of onsite technical support—someone to set up, trouble-shoot and fix the machines—is usually necessary.

However, sites are increasingly realizing that it's not just technical expertise that is required of good support resource personnel. Some technology-using educators are arguing that a new kind of professional is needed in schools—conversant in the technical issues but also experienced and knowledgeable about teaching methods, curriculum, students, and instructional design.

Although most sites have made significant progress in helping teachers learn to use generic tools such as word processing, graphics, and desktop publishing, many are struggling with how to integrate technology into the curriculum. **Supporting teachers in their efforts to integrate technology throughout their teaching is central if technology is to become a truly effective educational resource, yet true integration is a difficult, time-consuming, and resource-intensive endeavor.** In many places technology is treated as a content area separate from the basic curricular areas. Students and teachers are expected to become skilled in using technological tools. Yet few resources and expertise are available to help teachers put the technology to work in delivering curriculum in traditional content areas, such as English, math, or social studies. Learning to use the hardware and master the software tools is not enough; learning how to teach with technology—harnessing the tools for instructional ends—is a much more complex and lengthy process.

If the goal of using technology is to change how teachers teach and how children learn (for example, adopting more cooperative learning or more student projects), then teachers will need support and training to learn new pedagogical methods as well. **More technology or more use of technology will not be sufficient to assure other innovations or reforms.** As discussed above, teachers and administrators also should have a shared educational philosophy and a shared vision of how technology can facilitate that philosophy.

To get going, many technology programs have had to rely on a few particularly eager and dedicated teachers in a school. However, burnout can also be a real problem for these teacher-innovators, who are actively exploring technology resources, trying to keep up with new developments, and helping their colleagues. If a site truly wants to encourage its expert teachers to help their colleagues, these individuals could be compensated and recognized for their efforts.

Although enthusiastic individuals may help spark technology efforts, experience suggests that schools should not rely exclusively on a small cadre of "gurus." **As a long-term strategy for continued technology use, expertise should be shared among multiple individuals at a single site.** It is easy for a school to fall back on a technology guru who knows how to fix computers when they don't run and can suggest new strategies for using technology. But technology gurus may move to a new school, leaving the original school without a resource. Training multiple individuals increases the chances that expertise will remain.

Furthermore, **students can be effectively tapped as resources to help teachers with technology.** At some sites, teachers bring a student or two along to workshops or other learning experiences. They are eager, available, and "free" (see chapter 2). Some knowledgeable students become great resources for the teacher. However, this requires a teacher comfortable with letting some of the expertise reside with the student.

Incentives

Programs that seek to involve a large number of teachers should identify incentives that encourage teachers to use technology. Many teachers will not be motivated by the mere presence of more technology in their classrooms, but they can be motivated by a concrete vision of how it can help them meet their instructional goals. For example, encouraging teachers to find their own favorite uses of technology or develop specific areas of expertise can be an effective long-term strategy. As noted above, putting technology in the hands of teachers can be a good motivator for teachers. Some districts have given teachers computers as a "reward" for undertaking training.

Sites also have found that they may have to accept that some teachers will never really become interested in using technology. An alternative approach is to focus on gaining the interest and acceptance of a critical mass of teachers. For example, the technology coordinator in Bellevue, Washington, described three types of teachers: about 10 percent are the self-taught enthusiasts, highly motivated, who will try anything; about 60 percent are those making "hesitant progress," who like to take the classes and want to participate in technology in classrooms; and about 30 percent are resistant, don't take the class, or come only to get specific help with a particular problem. To reach this last group, Bellevue has encouraged more onsite inservice activities, conducted by a teacher in the building.[80]

Administrative and Community Backing

The role of the principal is crucial in promoting school technology use. Similarly, for technology to become diffused across a district, leadership by the central administration, especially the superintendent, is critical. These findings are supported by the organizational change research, which has consistently found that **change efforts do not succeed without active administrative leadership, particularly by principals**. Research has shown that leaders perform four important tasks: "(a) obtaining resources, (b) buffering the project from outside interference, (c) encouraging staff, and (d) adapting standard operating procedures to the project."[81]

Community support and understanding of the goals of technology use are also critical. Lessons from experienced sites indicate that without community support and buy-in, many new ideas fail to take hold in schools. Teachers and school administrators can educate and convince the community of the necessity and importance of their particular educational vision. As one noted researcher writes:

> An essential partner in any kind of educational regimen is the community, represented by many individuals ranging from respected elders to powerful business people and officials elected at the local and the national levels. In the United States today, probably the most important agents of change in the community are the parents, in their dual roles as advocates for their children and citizens of the society. . .If the

[80] Mergendoller et al., op. cit., footnote 3.

[81] Firestone and Corbett, op. cit., footnote 45, p. 330.

> community fails to support the desires and standards of school people, the educators are destined to fail.[82]

Conclusions About the Process of Implementation

If there is a single overarching lesson about the process involved in these efforts it is that **effective technology implementation takes more time and effort than many anticipate when first undertaking technology initiatives.** Based on the experience of sites visited for this report, and reports in the literature, it appears that five years may be an appropriate time frame for large-scale technology infusion. Change is not sudden and dramatic; it takes hard work on the part of many people over time to see the benefits of these endeavors.

None of the schools or districts portrayed here has experienced a smooth or uncomplicated process of technology training and implementation. Changes have been continually necessary to overcome unforeseen obstacles, such as staff reassignments, delays in equipment delivery, gaps between technology knowledge and utilization, or budget cuts, or to capitalize on unexpected success. State, district, and school-technology staff have continually revised their technology implementation plans based on evaluation results or unexpected events.

Some sites have found that small efforts that focus on one educational need or goal can be an effective way to get started using technology. For example, technology implementation in the Monterey Model Technology Schools was instituted one classroom at a time, based on the teacher's Classroom Intervention Plan. Similarly, at Webster Elementary School in St. Augustine, Florida, teachers with expertise in a particular application became the role models for their colleagues. By staying small and focused, specific goals can be addressed and successful outcomes are more likely. Initial success engenders enthusiasm, interest, and confidence, which then begets more success.

Evidence clearly indicates that when conditions are right—resources, time, and support are high—exciting things happen in technology-rich school environments. A key issue today is how to disseminate broadly the lessons of certain schools. How can the technology tools and knowledge be shared with schools whose resources are not as rich? Or when teachers are not as enthusiastic, energetic, or motivated? Who can help to support states and districts in promoting and disseminating successful strategies (see chapters 1 and 6)? Future efforts should focus on better and more comprehensive dissemination strategies and on ways to seed more projects in more challenging school environments.

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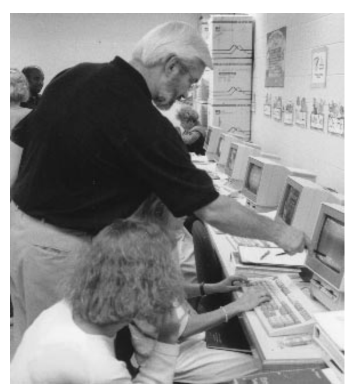
[82] Howard Gardner, *The Unschooled Mind* (New York, NY: Basic Books, 1991), p. 255.

Technology and the Preparation of New Teachers 5

SUMMARY OF KEY FINDINGS

- The need to prepare new teachers to use technology effectively is beginning to receive more attention in state certification standards for teachers, in accreditation standards for colleges of education (COEs), and in various efforts to reform and upgrade teacher education. State policies and leadership still vary widely, however, as does the extent of attention to technology in teacher preparation programs. Moreover, there has been little incentive to link reforms in colleges of education with reform of K-12 schools.
- Technology is not central to the teacher preparation experience in most colleges of education. Consequently, most new teachers graduate from teacher preparation institutions with limited knowledge of the ways technology can be used in their professional practice.
- Most technology instruction in colleges of education is teaching *about* technology as a separate subject, not teaching *with* technology across the curriculum. The majority of teacher education faculty do not model technology use to accomplish objectives in the courses they teach, nor do they teach students how to use information technologies for instruction. Seldom are students asked to create lessons using technologies or practice teaching with technological tools.
- Placing student teachers with technology-using teachers in technology-rich environments can provide valuable apprenticeships and can extend the quality and quantity of "hands-on" technology experience for many teacher candidates. Many K-12 schools have better technology facilities, and more experienced technology-using staff than do colleges of educa-



tion; however, technology is not always considered as a factor for student placements. Furthermore, schools where students do practice teaching may not be located near the colleges of education, increasing the difficulty of placing teacher education candidates in classrooms with the teachers who best model effective technology use.

- Video can extend the range of student observation into classrooms with the best teachers, wherever they are located. Whether live broadcasts from a classroom or tapes, they can provide teacher education students with models of effective teaching and the opportunity for reflection on what constitutes good teaching. Video can also document case studies and record observations for teacher education students to discuss and reflect upon in greater detail after a lesson has been presented.
- College of education administrators—especially deans—are key players in any effort to improve teacher preparation programs. Yet they are often constrained by the fact that colleges and universities have not provided the financial support necessary for supplying COEs with the state-of-the-art equipment needed for preparing their graduates. Furthermore, as in the K-12 schools, investments by COEs in hardware and software are rarely matched with those for faculty training and support.
- Models of change exist and can provide lessons for those seeking to build a bridge between reform of K-12 education and reform of teacher education, using technology as a resource for change and as a solution to some common problems in teacher preparation. However, the diversified nature of teacher education makes dissemination of these models difficult without federal leadership and support.
- Technology can forge stronger connections among student teachers, mentor teachers in classrooms, and university faculty, whether through lab schools, professional development schools, or traditional student placement activities. Students can connect to mentoring and information resources over great distances, expanding opportunities for apprenticeships.
- Electronic networks can provide a safety net for communication, knowledge, and experience for student teachers in the field, as well as for new teachers launching their careers. The loneliness and anxiety of the first teaching experiences can be mitigated through contact with professors and peers via electronic networks.
- If coverage of information technologies is to break out of the isolated role it plays today and become an integral part of the teacher education curriculum, several things must happen. K-12 and university educators must work together to integrate technology into curriculum and classroom practice; teacher educators and K-12 staff must receive considerable technology training and support; models must be developed with technology supporting specific content areas; and teacher education faculty incentives must be revised to encourage greater use and integration of technology for instruction.

INTRODUCTION

There are approximately 1,300 institutes of higher education preparing future teachers in this country. In the 1990-91 school year, nearly 100,000 students graduated with a bachelor's degree in teacher education in the United States.[1] In the next decade, the nation's schools will need to hire about two million teachers.[2] (See box 5-1.)

Ideally these new teachers should be able to use a range of technological tools to provide effective instruction and help their students become comfortable with and knowledgeable about technology. The most direct and cost-effective way to

[1] National Center for Education Statistics, *Digest of Education Statistics 1993*, U.S. Department of Education, OERI, NCES 93-292 (Washington, DC: October 1993), p. 250.

[2] Ibid.

BOX 5-1: Factors Affecting the Demand for New Teachers

The number of teachers needed in our nation's schools is greatly affected by population changes such as those caused by birth or immigration rates. Projections indicate that the school-aged population is growing. As a result, if current policies such as pupil-teacher ratios remain the same, schools will need about 3,3 million teachers by 2003—1.4 million more than are currently employed. Furthermore, the amount of teacher turnover,[1] which accounts for the largest proportion of the demand for new teachers, is projected to increase each year between 1993 and 2000. Much of this is due to increasing retirement rates as the teacher workforce ages.[2] Even retirement rates, however, are not predictable.

The teaching force is unbalanced with respect to age and experience. Younger teachers—those under 35—are a smaller portion of the teaching force than at any time in the last 25 years, and half of all teachers are over 42, making them eligible to retire at age 55—within 13 years. An important supply-and-demand question is how soon these retirements will occur, and thus when replacement will be needed. Current retirement patterns show a strong tendency for teachers to stay until 62 or 65. If this is the case, then demand for new teachers will increase more slowly. Budget problems in states could make early retirement offers very attractive—in fact, epidemic. Replacing older teachers with younger teachers significantly reduces education costs, even with somewhat increased retirement costs [3]

What about newly qualified teachers? How many of them go into teaching and for what reasons? About 32 percent of newly qualified teachers who were teaching in 1987 reported that they became teachers because they enjoyed working with children, 30 percent because they found teaching satisfying, and 28 percent because they had always wanted to be a teacher. However, despite their training, 28 percent of those newly qualified for teaching did not apply for a teaching job.[4] An examination of all 1985-86 bachelor's degree recipients who were newly qualified teachers suggests that 58 percent were employed as teachers the year after they graduated, 31 percent were employed in jobs other than teaching, and 11 percent were not employed.[5]

[1] Defined as the number of teachers leaving current positions.
2 National Center for Education Statistics, projections of education statistics to 2003 (Washington, DC December 1992), pp. 72-76.
[3] National Research Council, *Teacher Supply Demand, and Clarify* (Washington, DC. 1992), pp. 275-276
[4] National Center for Education Statistics, *American Teachers: Profile of a Profession* (Washington, DC May 1993), p. 125
[5] Ibid., p. 27.

educate teachers about technology is through the preservice education they receive in colleges of education or other institutions.

What is the role of technology in current teacher preparation programs? To what extent do states, COES, and national bodies for reforming teacher education recognize the potential and importance of technology? How do the COES that are leaders in technology approach preparation? This chapter seeks to address these questions.

HISTORY AND CURRENT CHALLENGES OF PREPARING TEACHERS

One of the most important tasks of society is to ensure that each successive generation acquires the knowledge, technologies, skills, and customs essential to maintain that society. For over a century, the primary responsibility for carrying out this task has rested with the *institution* of the American public school—and more specifically with the American school teacher.[3]

The history of teacher preparation has been one of changing expectations. In the 17th and 18th century teachers—like doctors and lawyers—had no formal educational requirements as prerequisites for practice. Those who taught elementary subjects were expected to know how to read, write, and do basic arithmetic so they could teach these skills to their charges. The most highly educated were those who taught in the private secondary schools, a group made up predominantly of clergy. During colonial times, teacher quality was variable; some teachers were barely literate while others possessed a college degree. The importance of religious orthodoxy was one noteworthy constant. Few considered teaching their primary career or goal in life.[4]

In the first decades of the 19th century, the "common school" was established in New England. Common schools created a tradition of education that was free, supported by taxes, and universally available to all students. With the surge in students attending common schools, it became clear that a formal, institutionalized approach to preparing teachers was necessary.

Although the first documented school for the training of teachers in the United States opened under private auspices in Concord, Vermont, in 1823,[5] it was the development of "normal schools" by Horace Mann in 1839 that promised to fill the glaring shortage of qualified teachers and to define teacher competence. Mann's vision aimed for "a new kind of school, a new kind of profession, the principle of taxpayer support and a new vocation for women."[6] With these innovations, the Lexington Normal School opened in July 1839.

Although growing numbers of 19th century teachers attended normal schools, others took part-time or short courses, and some continued to have little or no formal preparation for teaching. In the Midwest and West, the line between normal schools and post-elementary schooling blurred, as the normal school became a place where parents sent their children for a higher education, a sort of academy or high school rather than an institution for training teachers. As normal schools evolved into the model for general secondary schooling in the Midwest and West, their contributions to teacher training grew uneven.

Later, when normal schools evolved into teachers' colleges and then into colleges of education within larger institutions of higher education, differences of opinion emerged about whether the colleges' main goal should be the preparation of teachers or education theory and research. It might be said that normal schools evolved from single-goal institutions to lower-level institutions within the higher educational hierarchy. As one educator observed, "Thus, the normal school developed into a pale imitation of the university, doing what the university does, namely research, less well than the university, and not wishing to do well what it historically did—prepare teachers."[7]

Even after normal schools, and then teachers' colleges, had become widespread, a sizable pro-

[3] See, e.g., James Bosco, "Schooling and Learning in an Information Society," OTA contractor report, Washington, DC, November 1994.

[4] Wayne J. Urban, "Historical Studies of Teacher Education," in W. Robert Houston et al. (eds.), *Handbook of Research on Teacher Education* (New York, NY: Macmillan, 1990), p. 60. See also L.A. Cremin, *American Education: The Colonial Experience 1607-1783* (New York, NY: Harper & Row, 1970).

[5] Richard J. Altenbaugh and Kathleen Underwood, "The Evolution of Normal Schools," in John I. Goodlad et al., *Places Where Teachers Are Taught* (San Francisco, CA: Jossey-Bass Publishers, 1990), p. 137.

[6] Ibid., p. 138.

[7] Urban, op. cit., footnote 4. See also Cremin, op. cit., footnote 4.

portion of teachers still lacked much formal training well into the 20th century; as recently as 1940, less than 50 percent of the teachers in the United States held a bachelor's degree.[8]

The education of educators has obviously reached higher ground in recent decades; today, almost all teachers (99 percent) have at least a bachelor's degree, and almost half (46 percent) have a master's degree or higher.[9] Nevertheless, other factors bedevil teacher preparation programs, including misconceptions about teaching as a profession; misinformed perceptions of the intellectual capabilities of teachers; and negative stereotypes of women and minorities, who traditionally make up a large part of the teaching force.[10]

Teacher education programs today must address countless areas-usually within a time frame of three to four years, at best. Teacher education graduates not only need to be skilled in content, methods, cognitive development, assessment practices, pedagogical theory, education history, technology, and classroom management, but they may also need to know about drug education, AIDS, environmental issues, social and family issues, and whatever else the public decides schools should handle. Although, ideally, "the mission for teacher education should arise out of the mission for schooling," the problem is that the mission of schooling is itself unclear, indeed, schools in general operate under "fragmented goals."[11]

Technology may present an extra burden to some colleges of education, but many find it essential to a strong teacher education program.

Schools have a difficult task keeping up with changes in what society asks of them. For colleges of education to anticipate these redefinitions in their teacher preparation programs is a daunting task.

REFORM IN TEACHER EDUCATION

The way that new teachers are prepared is often under public scrutiny-in the media and press,[12] as well as by educators themselves. Many colleges of education across the country have tried to implement reforms that address public concerns, yet

[8] Richard I. Arends, "Connecting the University to School," in Bruce Joyce (ed.), *Changing School Culture Through Staff Development* (Washington DC: Association for Supervision and Curriculum Development, 1990), p. 118.

[9] Natioal Center for Ecucation Statistics, *Schools and Staffing in the United States: A Statistical Profile,* 1990-91, OERI, NCES 93-146 (Washington, DC: U.S. Department of Education, July 1993), pp. 39,42.

[10] Judith E. Lanier, "Choices for the Twenty-First Century: Will Universities Strengthen or Close Schools of Education?'' vol. LXXIII, No. 4, Phi Kappa Phi Journal, fall 1993.

[11] John I. Goodlad, *Technos,* vol. 2, No. 3, fall 1993, p. 5.

[12] See, e.g., Thomas L. DeLoughry, "EDUCOM conference Focuses on Ways To Improve Teaching," *Chronicle of Higher Education*, vol. XLI, No. 11, Nov. 9, 1994, p. A21. Also, David L. Clark and Terry A. Astute, "Redirecting Reform" Phi Delta Kappan, vol. 75, No. 7, pp. 513-520.

the skepticism persists: some think undergraduate programs produce classroom teachers with limited expertise in the subjects they are expected to teach, while graduate schools prepare specialists who spend little time in classrooms; others find the form and format of teaching in colleges of education antithetical to "real" learning, with those who prepare classroom teachers modeling the "chalk and talk" lecture teaching style. Many observe that there is never enough time for students to be exposed to good teaching or for student teaching under the watchful eye of a competent supervising teacher, nor enough top-notch teachers in model classrooms close enough to the college of education to provide enough successful student teaching placements.

In November 1994, the National Commission on Teaching and America's Future began an 18-month exploration of the profession. It bemoaned "shortfalls" and "woeful neglect of teaching" while addressing new approaches to the problems teachers face amid "challenging new education demands." The commission plans to "identify successful strategies to resolve teacher shortages, especially in urban areas and in math and science, as alternatives to hiring unprepared teachers."[13]

Unprepared teachers are only part of the problem. The interaction between K-12 schools and teacher education programs is an important, generally overlooked variable. In the words of one educator,

> If schools are to be good, the general and professional education of those who teach in them must also be good. If teacher education is to be good, the schools in which future teachers receive a significant part of their preparation must also be good.[14]

Colleges of education, state departments of education, and professional associations have tried many approaches over time to standardize, improve, and professionalize teacher preparation. For example, the National Council for the Accreditation of Teacher Education (NCATE) has developed a "Continuum of Teacher Preparation" that includes quality-assurance measures in three phases—preservice, extended clinical preparation and assessment, and continuing professional development. The continuum depends upon cooperation and coordination with the state education authorities, school districts, and other professional organizations, such as the National Board for Professional Teaching Standards (NBPTS).[15] Additional reform efforts involve developing new models of interaction between COEs and K-12, improvements in teacher certification and licensure procedures, and changes in the accreditation of schools and colleges of education. Technology can play a role in all these efforts.

Rallying Calls for Teacher Education Reform

The release of the report *A Nation at Risk*[16] a decade ago brought public awareness of the quality of American schools to a new high; nevertheless, colleges of education and their professors were neither leaders of the charge to reform, nor considered key elements in implementing change. Two major reports released in the late 1980s began to change this trend. The reports of the Carnegie Forum on Education and the Economy[17] and the

[13] The National Commission on Teaching and America's Future was created through funding from the Rockefeller Foundation and the Carnegie Corporation to establish "a national blueprint to determine how teachers in all communities can be supported and prepared to meet the needs of the 21st century classroom."

[14] John I. Goodlad, "The National Network for Educational Renewal," *Phi Delta Kappan*, April 1994, p. 632.

[15] Arthur E. Wise, Director, National Association for the Accreditation of Teacher Education, personal communication, Nov. 9, 1994.

[16] National Commission on Excellence in Education, *A Nation at Risk* (Washington, DC: U.S. Government Printing Office, 1983).

[17] Carnegie Forum on Education and the Economy, *A Nation Prepared: Teachers for the 21st Century* (Washington, DC: 1986).

Holmes Group[18] addressed improvements in the preparation of new teachers as a key link to educational reform. In addition, the American Association of Colleges for Teacher Education (AACTE) and the Association for Teacher Education made efforts to codify knowledge needed by new teachers.[19]

In its 1986 report, *A Nation Prepared: Teachers for the 21st Century*,[20] the Carnegie Forum's Task Force on Teaching as a Profession—made up of business and government leaders and union and school officials—called for sweeping changes in education policy. Among the eight recommendations, two were specific to the preparation of new teachers: 1) require a bachelors' degree in the arts and sciences as a prerequisite for the professional study of teaching; and 2) develop a new professional curriculum in graduate schools of education leading to a Master in Teaching degree, based on systematic knowledge of teaching, internships, and residencies in the school.[21]

Another influence for reform has been the Holmes Group,[22] a coalition of deans from the graduate schools of education at research universities that, in 1983, began a study of ways to reform teacher education and the teaching profession. Their 1986 report, *Tomorrow's Teachers*,[23] developed a common agenda that included eliminating the undergraduate education major, strengthening and revising both the undergraduate curriculum and graduate professional training of teachers, creating new professional examinations for entry into the profession, and connecting higher education institutions to schools, through the development of *professional development schools*. Professional development schools are places where both teachers and university faculty can systematically inquire into and take part in teaching practice to improve it.

The Holmes Group's agenda has not met with universal acceptance. Many educators have decried the exclusivity of the organization; other educators were concerned about the creation of one specific model of teacher preparation, especially one that required—as the Holmes Group's did—a four-year liberal arts major followed by a fifth year of graduate study in education. Another sticking point has focused on problems associated with the content, cohesiveness, and quality of instruction prospective teachers receive in the colleges of arts and sciences. Some have been concerned that the fifth-year model the Holmes Group advocates may not provide enough time for potential teachers to take all the requisite courses, observe teachers, participate in internships, and develop teaching skills in their subject matter specialties.

The group's most recent report[24] reiterates the value of professional development schools and emphasizes the need to make COEs accountable to their profession and to the public. In addition, the new report says Holmes plans to create alliances with other organizations, such as AACTE

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[18] Holmes Group, *Tomorrow's Teachers: A Report of the Holmes Group* (East Lansing, MI: 1986).

[19] M.C. Reynolds (ed.), *Knowledge Base for the Beginning Teacher* (Elmsford, NY: Pergamon Press, 1989); W.R. Houston (ed.), *Handbook of Research on Teacher Education* (New York, NY: Macmillan, 1990).

[20] Carnegie, op. cit., footnote 17.

[21] Ibid., p. 3.

[22] Starting as an informal consortium of 17 education deans, the group took both name and mission from Henry Holmes, Dean of Harvard Graduate School of Education, who in 1927 suggested, "America has yet to be persuaded that the training of teachers is a highly significant part of the making of the nation." Lynn Olson, "An Overview of the Holmes Group," *Phi Delta Kappan*, April 1987, p. 691. Today the group includes deans of more than 80 education schools in research institutions.

[23] Holmes Group, op. cit., footnote 18.

[24] Holmes Group, *Tomorrow's Schools of Education* (East Lansing, MI: 1995).

and national teachers' unions, to support reform efforts in teacher preparation.[25]

Certification and Licensure of New Teachers

The education systems being challenged by current reforms are based on a legacy begun in the 19th century, when many states took over the functions of examining and credentialing new teachers. Typically, the state departments of education controlled public normal schools (and later teachers' colleges), and certification became a question of completing the course of instruction offered by these institutions. Today, state requirements for teachers are created by state legislatures. However, because public school teachers are employed by local boards of education (on the recommendation of the superintendent of a district), and these boards are made up of lay people, it might be said that the public is involved in employing teachers. Thus there is a divided responsibility—among the public sector, universities and colleges, and public schools—for what should be the basis of teaching.

In other professions—medicine, law, engineering, architecture—states have delegated the responsibility for licensing to autonomous standards boards composed of practitioners who establish the standards and processes of the profession for the nation. Teaching does not follow this model.[26] Instead, each state sets its own licensure or certification process for educators[27] and issues different types of certificates. In some cases, state departments of education determine qualifications to teach based on a requisite number of courses. State approval generally comes from reviewing specific teacher education programs on a program-by-program basis, resulting in hundreds of sets of standards for teacher preparation with varying levels of quality. "The generally minimal state-prescribed criteria remain subject to local and state political influences, economic conditions within the state, and historical conditions which make change difficult."[28]

In general, there is a *standard* teaching license or certificate. Each state sets its own standards that individuals must meet by completing an approved teacher education program and fulfilling state or district continuing professional development requirements. (Half the states require students to take a state or national test prior to admittance to a teacher education program. See table 5-1.) States issue both *provisional* and *permanent* credentials. A provisional certificate means a teacher is adequately prepared for initial employment but must meet some additional conditions of further coursework or experience (or both) before receiving a *permanent* certificate. There are also *emergency* teaching certificates, usually issued on a yearly basis, for those who are not yet qualified to teach but who are needed in areas of shortages. Emergency certificates are also used for candidates who lack formal qualifications but whom a district wants to hire for special skills or other reasons.

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[25] Ann Bradley, "Holmes Group Urges Overhaul of Ed. Schools," *Education Week*, vol. XIV, No. 19, Feb. 1, 1995, pp. 1, 8.

[26] Gail Huffman-Joley, "State Standards Boards Will Create a Stronger Profession," *Quality Teaching*, NCATE Newsletter, vol. 3, issue 1, fall 1993, p. 6.

[27] American Association of Colleges for Teacher Education, *Teacher Education Policy in the States: A 50-State Survey of Legislative and Administrative Action* (Washington, DC: spring 1994), p. vii. While the terms *license* and *certificate* are often used interchangeably, the Office of Technology Assessment uses the following terminology adopted by the American Association of Colleges of Teacher Education for its survey of teacher education policy: "A *license* is the official recognition by a state government agency that an individual has met state-mandated requirements and is therefore approved to practice as a duly licensed educator in that state. A *certificate* is a credential awarded by the profession in recognition of advanced skills or achievement. Some states use the term 'certificate' to describe what is more commonly referred to as a license. A *credential* refers to either a license or certificate."

[28] George M. Dennison, "National Standards in Teacher Preparation: A Commitment to Quality," *Chronicle of Higher Education*, Dec. 2, 1992, p. A-40.

Not all teachers today are prepared for their jobs. The National Commission on Teaching and America's Future suggests that, among the more than 200,000 teachers newly hired each year, one in four (50,000) are not fully prepared for their jobs. In the country's largest school district, New York City, more than half (57 percent) of the 4,500 teachers hired in 1992 were unlicensed. In fact, more than 15 percent of all schools and 23 percent of central city schools nationwide had vacancies in 1991 they could not fill with a qualified teacher.[29]

Alternative Certification

Alternative certification programs vary by state and are designed for nontraditional students taking accelerated preparation for teaching. Often, these programs are aimed at encouraging people with special skills or experience (such as retired military personnel) to go into teaching as a mid-career change. Many of those entering the profession through alternative preparation programs begin with emergency certification until they meet the full requirements of their teaching area.

After a period of expansion, the number of states offering alternative certification programs decreased from 43 in November 1993 to 36 in May 1994.[30] Some states have more than one alternative program for licensure; others have dropped alternative programs due to funding difficulties or lack of support from prospective students, school districts, or institutions of higher education. However, approximately 200 of the more than 500 colleges of education accredited by the National Council for Accreditation of Teacher Education still offer alternative certification programs.[31]

Some critics assert that alternative certification candidates lack sufficient pedagogical understanding, which is difficult to acquire after one begins teaching.[32] This is likely to become an even greater concern as standards for teacher education programs in general are raised.[33] Moreover, given the high attrition rate of beginning teachers in general, there is concern that those entering teaching without a strong base of pedagogical skills and experience may be particularly ill-prepared to handle troublesome settings.

Alternative certification does not automatically imply hiring outside the teaching profession, as some critics contend. It also provides a way to bring in qualified teachers from other states. For example, Oklahoma—in adopting the Master Teacher certification that has been developed by the National Board for Professional Teaching Standards—will waive its state certification for certified teachers from other states who pass the NBPTS certification assessments. NBPTS is developing advanced standards and assessments for teacher performance that encompass various components such as portfolios, certification center assessment activities, and essay examinations designed to demonstrate teacher knowledge and skill. Teachers who meet these standards will be designated as "Master Teachers."[34] In fact, this kind of flexibility for teachers who want to move

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[29] Linda Darling-Hammond, "The Current Status of Teaching and Teacher Development in the United States," background paper for the National Commission on Teaching and America's Future, New York, NY, November 1994.

[30] AACTE, op. cit., footnote 27, p. v.

[31] Wise, op. cit., footnote 15.

[32] See, e.g., Jonathan Schorr, "Class Action," *Phi Delta Kappan*, vol. 75, No. 4, December 1993, pp. 315-318.

[33] James B. Stedman, Congressional Research Service Report for Congress, "Teachers: Issues for the 101st Congress," Feb. 23, 1990, p. 21.

[34] See, e.g., Arthur E. Wise, "Professionalization and Standards: A Unified System of Quality Assurance," *Education Week*, June 1, 1994; and "The Coming Revolution in Teacher Licensure: Redefining Teacher Preparation," *Action in Teacher Education*, vol. XVI, No. 2, summer 1994, pp. 1-13. See also, Lynda Richardson, "First 81 Teachers Qualify for National Certification," *New York Times*, Jan. 6, 1995, p. A-1.

TABLE 5-1: State Requirements for Entrance to Teacher Education Programs[a]

State	State or national tests[b]	Minimum grade point average	University/college of education entrance standards	Other state requirements[d]
Alabama	✓	✓	✓	✓
Alaska			✓	
Arizona			✓	
Arkansas	✓	✓		
California	✓		✓	
Colorado	✓			
Connecticut	✓			✓
Delaware			✓	
District of Columbia	✓			
Florida[e]	✓			✓
Georgia	✓	✓	✓	
Hawaii			✓	
Idaho	✓	✓	✓	
Illinois			✓	✓
Indiana		✓		
Iowa			✓	
Kansas[f]	✓	✓		
Kentucky	✓	✓		✓
Louisiana[g]	✓	✓		
Maine			✓	
Maryland			✓	
Massachusetts			✓	
Michigan				✓
Minnesota	✓[h]			
Mississippi	✓	✓		✓
Missouri	✓			
Montana				
Nebraska	✓	✓		✓
Nevada	✓			
New Hampshire			✓	
New Jersey		✓		✓
New Mexico			✓	
New York				
North Carolina	✓	✓		
North Dakota		✓	✓	✓
Ohio			✓	
Oklahoma	✓	✓		
Oregon	✓	✓	✓	✓
Pennsylvania			✓	
Rhode Island		✓	✓	✓

TABLE 5-1 (cont'd.): State Requirements for Entrance to Teacher Education Programs[a]

State	State or national tests[b]	Minimum grade point average	University/college of education entrance standards	Other state requirements[d]
South Carolina	✓	✓	✓	✓
South Dakota		✓		✓
Tennessee	✓	✓		✓
Texas	✓			✓
Utah			✓	
Vermont		✓	✓	✓
Virginia	✓	✓		
Washington	✓	✓		
West Virginia				
Wisconsin	✓	✓		
Wyoming			✓	

[a]American Association of Colleges of Teacher Education, Teacher Education Policy in the States, A 50-State Survey of Legislative and Administrative Actions (Washington, DC. AACTE, 1994)

[b]For example, National Teachers Exam, Pre-Professional Skills Test, PRAXIS, California Basic Skills Test.

[c]Standards set by individual Institutions of Higher Education (IHE)/Schools and Colleges of Education.

[d]For example, interviews, other demonstrations of basic skills competencies, course requirements.

[e]Up to 10 percent of an IHE's admission may be to individuals who do not meet standards

[f]Standards are for regents restitutions only

[g]Up to 10 percent of an IHE's admission *may be to* individuals who do not meet standards, but candidates will have to meet standards for licensure

[h]State requires candidates to take the Pre-Professional Skills Test, but scores are not used for screening purposes. The low-scoring candidates are targeted for assistance.

[i]Minimum GPA requirement applies only to graduate program candidates, there is no minimum GPA requirement for undergraduate candidates

between states is one alternative measure NBPTS is encouraging nationwide.[35]

Technology and Certification

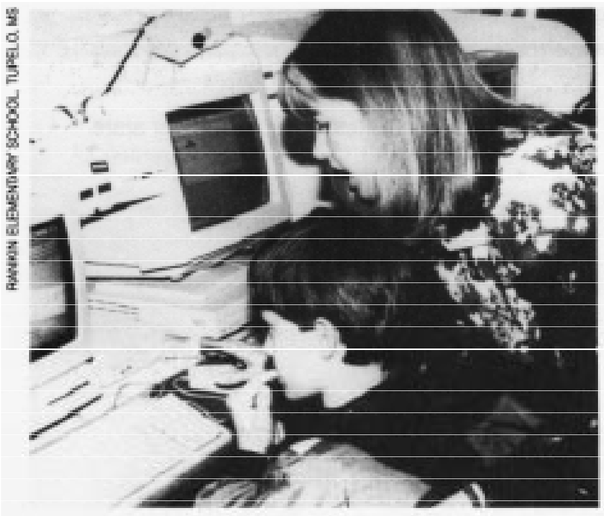
The importance of technology in teacher certification is gaining momentum. A recent survey under contract to the Office of Technology Assessment (OTA) found that at least 18 states require training in computers or technology for *all* teachers seeking certification.[36] Although that figure is far from a majority, it represents an increase over just a few years ago: in 1987 only 12 states had such a requirement for certification of all teachers.[37]

States take various approaches to technology certification requirements. For example, California requires a one-semester course, New Jersey and Texas require a three-credit course, and Kansas and Wyoming require a one-unit course. Washington state law specifies that all teachers must have general knowledge of instructional uses of the computer and other technological developments. In Michigan, recent legislation mandated that teachers have "a working knowledge of

[35] Joanna Richardson, "States Offer Incentives to Teachers Seeking National Board Certification," *Education Week, Sept. 7, 1994.*

[36] Ronald E. Anderson. "State Technology Activities Related to Teachers," OTA contractor report, November 1994.

[37] In addition to the 12 states that required computer-related courses for all teacher certification in 1987, six states had such requirements for teachers in certain subject areas (business, computer, or media education). U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and* Learning, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988), p. 209.



Technology is becoming more important for teacher certification. Eighteen states currently require training in computers or technology for all teachers seeking certification.

modern technology and use of computers" and that the university that graduates the teacher candidate "demonstrate [this knowledge] to the satisfaction of the school or district before an individual may engage in student teaching."[38] And since 1985, Idaho teachers have been required to "develop skills to use computer technology," including word processing, database management, and general instructional use. Idaho and Wisconsin, according to the survey, follow the preservice guidelines for technology training developed by the International Society for Technology in Education (ISTE) and approved by NCATE, the national professional accreditation body (see box 5-2).

Technology is also receiving heightened attention in some alternative certification programs. In Florida, an alternative preparation program connects institutions of higher education and local public or private schools with individuals from the military and business who have degrees in specific content areas needed by the schools. In this field-based preservice program, candidate practitioners work in classrooms as contracted fret-year teachers under the supervision of the teacher educators from the College of Education at the University of South Florida. A school-based team assists and evaluates the candidate's performance throughout the year. Technology proficiency is imperative in this model, since candidates are trained on and expected to use Florida's Information Resource Network (FIRN), a statewide teacher network, to communicate with each other and with the Alternative Teacher Preparation program office. Candidates use lesson plans distributed over FIRN and can take courses while off campus via distance learning.[39]

■ Accreditation of Colleges of Education

One of the major issues in the professionalization of teaching and teacher education is the accreditation of schools and colleges of education. Unlike those who practice law, medicine, social work, engineering, architecture, or other professions, teachers do not have to graduate from an institution accredited by the profession. In fact, today less than half the schools of education are professionally accredited.

There are two accrediting tracks for colleges of education: state standards boards and the National Council for Accreditation of Teacher Education. State standards boards have been created over the last 20 years, and now exist in 11 states.[40] Some are appointed by the governor, and a few report to the legislature. Some have complete responsibility for establishing standards and implementation procedures for licensure, while others have only

[38] See State of Michigan 87th Legislature, Enrolled House Bill No. 5121, sec. 1531b, Dec. 31, 1993.

[39] Molly Drake, University of south Florida, personal communication, December l994. The University, located in Tampa, currently serves seven Florida school districts with its Alternative Teacher Preparation program. See also, Eric Schmitt, "Peace Dividend: Troops Turn to Teaching:" New York Times, Nov. 30, 1994, pp. B-1, 12.

[40] Wise, op. cit., footnote 15.

BOX 5-2: Curriculum Guidelines for Accreditation of Educational Computing and Technology Programs

The Accreditation Committee of the International Society for Technology in Education (ISTE) in 1992 developed a set of "Curriculum Guidelines for the Accreditation of Educational Computing and Technology Programs," which was approved by the National Council for the Accreditation of Teacher Education. The basic guidelines suggest that all teachers should be able to:

1. Demonstrate the ability to operate a computer system in order to successfully use software.
2. Evaluate and use computers and related technologies to support the instructional process.
3. Apply instructional principles, research, and appropriate assessment practices to the use of computers and related technologies.
4. Explore, evaluate, and use computer/technology-based materials, including applications, educational software, and documentation.
5. Demonstrate knowledge of uses of computers for problem solving, data collection, information management, communications, presentations, and decisionmaking.
6. Design and develop student learning activities that integrate computing and technology for a variety of student grouping strategies and for diverse student populations.
7. Evaluate, select, and integrate computer/technology-based instruction in the curriculum of one's subject area(s) and/or grade level.
8. Demonstrate knowledge of uses of multimedia, hypermedia, and telecommunications to support Instruction.
9. Demonstrate skill in using productivity tools for professional and personal use, including word processing, database, spreadsheet, and print/graphics utilities.
10. Demonstrate knowledge of equity, ethical, legal, and human issues of computing and technology as they relate to society and model appropriate behaviors.
11. Identify resources for staying current in applications of computing and related technologies in education.
12. Use computer-based technologies to access information to enhance personal and professional productivity.
13. Apply computers and related technologies to facilitate emerging roles of the learner and the educator.

SOURCE: Excerpt from goals established by the International Society for the Accreditation of Technology in Education, Accreditation Committee, Eugene, OR 1992.

partial responsibility.[41] Most are autonomous and determine the credentials, licenses, standards, assessments, and examinations for entry and advancement in the profession. In most cases, the boards also approve specific college or university teacher education programs.

NCATE was created about 40 years ago, and its mission today is to establish and help support a quality system for preparing future teachers throughout schools of education. The reorganization of NCATE in 1986, with its subsequent adoption of a set of standards for teacher education in

[41] AACTE, op.cit., footnote 27, p. vi.

1988, has been another key force in teacher education reform. Until this restructuring, the organization accredited individual teacher education programs, a task which duplicated in many ways the state's function.[42] This might explain why colleges of education have found requirements for state program approval and NCATE accreditation to be duplicative, although both are voluntary.

There are other concerns with duplication, as well. Institutions must sometimes undergo multiple reviews to satisfy different kinds of requirements, including university system requirements, subject-specific curriculum guidelines in the 17 associations recognized by NCATE, and guidelines for programs such as math and English developed by the National Association of State Directors of Teacher Education and Certification (NASDTEC).[43] To minimize this potential for overlap, NCATE so far has entered into partnerships with 33 states to cooperate in their review of institutions.[44] For example, Florida has agreed that its state teacher education institutions need only undergo a single review rather than three different reviews by the state board, the university, and NCATE.[45]

NCATE's role as the national professional accreditation body has not been without controversy. As one educator asserts, "NCATE demands high standards but has no mechanism to really assist institutions in making the changes needed."[46] Although many suggest that accreditation is important to assure the public that institutions have met high standards and provide a philosophical and intellectual foundation for teacher education, only 521—or 41 percent—of the 1,279 state-approved teacher education institutions have sought and received NCATE approval.[47] (As of September 1994, 41 additional institutions are candidates, awaiting an accreditation visit.[48]) Furthermore, the National Board for Professional Teaching Standards (NBPTS) does not require that candidates for its advanced professional certification ("Master Teachers") be graduates of accredited teacher preparation programs. However, NBPTS and NCATE are working together "to ensure that standards for accreditation and standards for advanced certification are compatible and congruent."[49]

In revising standards in 1988 to reduce duplication, clarify language, and emphasize areas of importance, NCATE also placed a new emphasis on technology. The NCATE standard "Pedagogical Studies for Initial Teacher Preparation" suggests that professional studies for all teachers include knowledge about and appropriate experiences with eight areas, one of which is educational computing, including the use of computer and related technologies in instruction, assessment, and professional productivity. Under the standards for quality of instruction for teacher education faculty, a new indicator was added stating that "instruc-

[42] Ted Sanders, "A State Superintendent Looks at National Accreditation," *Phi Delta Kappan*, October 1993, pp. 165-170.

[43] See also the "1992 NASDTEC Outcome-Based Standards and Portfolio Assessment," a set of standards that serve as a resource for states considering, developing, or implementing outcome-based approaches for teacher education and certification.

[44] Jane Liebbrand, NCATE Director of Communications, personal communication, Sept. 23, 1994. See also, Karen Diegmueller, "NCATE Analysis of Education Schools To Help Forge Partnerships with States," *Education Week*, Mar. 24, 1993, p. 27.

[45] Wilmer S. Cody, "National Accreditation—An Effective Use of Resources," *Quality Teaching*, NCATE Newsletter, vol. 1, Issue 2, winter 1992, p. 1.

[46] Allen Glenn, Dean, College of Education, University of Washington, Seattle, personal communication, Jan. 6, 1995.

[47] Diegmueller, op. cit., footnote 44.

[48] Liebbrand, op. cit., footnote 44.

[49] Ibid.

tion reflects knowledge and use of various instructional strategies and technologies."[50] Qualifications for professional education faculty also must include "faculty modeling the integration of computers and technology in their fields of specialization." Finally, there is a standard to ensure that facilities, equipment and budgetary resources in the colleges of education are sufficient to fulfill its mission and offer quality programs. One indicator states that "facilities and equipment support education communication and instructional technology needs, including computers, and they are functional, and well maintained."[51] In addition, NCATE endorsed the curriculum guidelines for educational and computing technology programs developed by ISTE (see box 5-2).

Another organization acting as a catalyst to reform and improve the standards of teachers is the Council of Chief State School Officers (CCSSO). The CCSSO's task force on licensing standards, called the Interstate New Teachers Assessment and Support Consortium (INTASC), is working to develop common licensing standards for new teachers, from the perspective of the state departments of education. INTASC has worked with 22 states over the last three years to develop model standards that require teachers to demonstrate knowledge and skills; the new standards are intended to replace the current teacher preparation program approval system with a system based on achievement.[52] Both the CCSSO and NBPTS are also National Council for Accreditation of Teacher Education constituents, so the platform is being set for shared expectations for teacher education reform.

In addition, the National Association of State Directors of Teacher Education and Certification has published a set of model standards as resources for states considering outcome-based approaches to teacher education and certification. It is a first step in developing essential national standards for obtaining the initial professional teaching certificate and entering the teaching profession. In the future, NASDTEC plans to work with states to develop instruments, tasks, and materials for evaluating whether prospective teachers have the skills, attitudes, and knowledge for teaching. NASDTEC also plans to develop tools such as multimedia professional development systems and portfolio assessment models for demonstrating competence in teaching with technology.

Technology is also central to the NASDTEC outcomes, both as a separate subject area and integrated with content areas across the curriculum. For example, one standard states that "the beginning (high school) teacher during planning, delivery, and analysis activities correlates, integrates, and applies computer-supported learning, production, and management systems in classroom teaching," in order "to broaden student knowledge about technology, to deliver direct instruction to all students at different levels and paces, to use technology as a motivation for higher order learning, and to produce computer assisted solutions to real-world problems."[53]

K-12 Reforms, Colleges of Education, and Technology

Reform efforts that link colleges of education and K-12 schools are not commonplace, but such collaborations are vital if the current teacher workforce and future teachers are expected to be able to approach teaching and learning in an effective, cohesive manner. Typically, K-12 reform and col-

[50] The International Society for Technology in Education recommended NCATE's adoption of this standard. Margaret Kelly, California State University, San Marcos, personal communication, Sept. 13, 1994.

[51] National Council for the Accreditation of Teacher Education, "NCATE Standards" (Washington, DC: 1994).

[52] Arthur E. Wise, "Professionalization and Standards: A 'Unified System of Quality Assurance,'" *Education Week*, June 1, 1994, p. 48.

[53] NASDTEC Standards Committee, "NASDTEC Outcome Based Standards" (draft), March 1993, p. 19.

MISSISSIPPI STATE UNIVERSITY

At Mississippi State University elementary teachers from around the state are trained to use multimedia computer equipment for a new 8th-grade course called Computer Discovery that helps students understand how computers are used in different careers.

leges of education reform are viewed as separate issues.[54] Indeed, "during the past 100 years or so of focusing on school reform, very little attention has been paid to the role of reforming teacher education."[55]

This situation is no different when it comes to technology education and implementation. **COE faculty rarely work with other agencies, such as school districts or state education agencies, on projects related to technology integration, according to data from the survey conducted for OTA.**[56] Likewise, many teacher education faculty are not aware of all the technology requirements for teacher certification in their states.

Often at the state and federal level there is little understanding of what this alignment between COEs and K-12 requires. Nevertheless, some collaborative partnerships among universities, schools, districts, regional education agencies, and state education agencies have shown great promise. For example, the University of Virginia teamed up with the Virginia state education agency to create Virginia's Public Education Network. California State University's telecommunications system spawned a collaborative, statewide K-12 staff development project, the California Technology Project, supporting free K-12 telecommunications and preservice teacher links.[57] Faculty at the University of Central Florida and the University of South Florida have been very active in technology training and development projects in collaboration with the Florida state education agency. And the Texas Education Agency's grant program supports technology-rich professional development schools (see box 5-3).

At the University of Washington, three reform efforts-the Center for Educational Renewal, the Institute for Educational Inquiry, and the National Network for Educational Renewal—are jointly creating an agenda for the simultaneous renewal of pre-kindergarten through grade 12 schools and the education of educators. Twenty-five universities and 100 school districts are linked by the National Network as part of this undertaking, and the Institute supports work at the educational settings involved in the network.

> The renewal of teacher education requires the availability of schools that are in the process of renewing. Schools that are renewing are as indispensable to good teacher education as teaching hospitals are to good medical education.[58]

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54 John. I. Goodlad, *Teachers for Our Nation's Schools* (San Francisco, CA: Jossey-Bass, Inc., 1990).

55 Goodlad, op. cit., footnote 14.

56 Jerry Willis et al., "Information Technology in Teacher Education: Surveys of the Current Status," OTA contractor report, March 1994.

57 Kelly, op. cit., footnote 50.

58 Goodlad, op. cit., footnote 14.

Indeed, in the 19 institutions of higher education in the state of Washington, teacher education students are placed in schools the very first quarter of their teacher education programs. At the University of Washington, 60 hours of school-based experience is required to be considered for admission to the teacher education program.[59]

The professional development school movement[60] is a similar example of a K-12 and university collaboration. Institutions such as the University of Utah and the University of Houston have forged relationships with public schools to increase opportunities for teacher education students to observe and practice technology integration. Both Utah and Houston have discovered, however, that university faculty and K-12 teachers require considerable staff development and ongoing support to make the connections. Unless university policies (e.g., tenure, promotion, and merit salary increases) are changed to reward COE faculty for undertaking collaborative projects with K-12, there is little incentive for faculty to invest the substantial time and effort required for working closely with schools.

Increased COE collaboration with K-12 must be balanced against the additional drain on the limited technology and support resources available in colleges of education. As discussed in the section below, these COE technology resources are limited.

TECHNOLOGY IN TEACHER EDUCATION

Among the many demands on schools and colleges of education today, preparing teachers to use technology may seem like an additional burden. However, as noted above, states and professional organizations are increasingly recommending or requiring that all new teachers be competent in the uses of technology. **Moreover, emerging evidence suggests that technology can make several positive contributions to the overall preservice experience.**

For example, OTA case studies of four colleges of education where technology is an integral part of the preservice programs found technology being used in a number of ways to enhance the overall teacher preparation experience.[61] Technology can capture the reality of the classroom: a videotape of a teacher conducting an actual class can "anchor" preservice students to the complex and real-life interactions of students and teachers. Technology can facilitate access to and communication with additional resources, such as experts in the field or informational databases on CD-ROM available to teacher education students and faculty on the same network. Technology can also support and enhance traditional approaches to teacher-developed curriculum materials and instructional practices. While these kinds of programs demonstrate the possibilities, the underlying question remains: how well do most colleges of education prepare new teachers to use technology?

Preparing New Teachers To Use Technology

A Role for Colleges of Arts and Science

Teachers teach as they have been taught. Since most teacher education students receive much of their content instruction in the colleges of arts and sciences, it is important that effective teaching—including teaching with technology—is modeled in the other parts of the university preparation of prospective teachers. This is particularly important as states cut back the number of education courses a prospective teacher can

59 Glenn, op. cit., footnote 44.

60 See, e.g., Linda Darling-Hammond (ed.), *Professional Development Schools: Schools for Developing a Profession* (New York, NY: Teachers College Press, Columbia University, 1994); also, Joanna Richardson, "NCATE To Develop Standards for Training Schools," *Education Week*, vol. XIV, No. 19, Feb. 1, 1995, p. 3.

61 John R. Mergendoller et al., "Case Studies of Exemplary Approaches to Training Teachers to Use Technology," OTA contractor report, September 1994.

BOX 5-3: Redefining Preservice, Texas Style

Attending faculty meetings; participating in PTA meetings; going on field trips; observing and assisting in the library in the nurses clinic and counselor's office, and sitting in on parent conferences. No, it's not a day in a teacher's life. It's a semester in the life of preservice teacher candidates fulfilling an internship in Texas.

For example, at the Center for Professional Development and Technology (CPDT) at Stephen F. Austin University's School of Education, instead of three-and-a-half years of university coursework and a semester of student teaching, preservice teacher candidates must spend a semester as an intern-observing, learning, and taking university classes at a school site—prior to becoming student teachers. The teacher candidates are involved in all aspects of school activity They tutor individual students, teach in small groups, make bulletin boards, use computerized grade books, shadow mentor teachers in various assignments, and attend inservice training programs.

In a typical internship at a middle school, for example, teacher candidates spend an eight-hour day at the school two days a week, from the first bell in the morning until one in the afternoon, they are teacher interns working with a mentor teacher. Later in the day, they become university students again, taking methods courses taught by university faculty on-site at the middle school. During the rest of the week, the students return to the university to take regular classes, including a course using computers purchased with CPDT funds. The students get computer experience in their school sites, too, using technology (also funded with CPDT monies) in the mentor teachers' classrooms.

Often, this school-based experience is enough for students to decide whether or not they really want to become teachers. For the teachers in the school, the experience is also an education. As one teachers says, "The old student teachers would just take courses and come straight into the classroom, with no buffer zone. Now . . . we have student teachers who have seen what a school is about. " Teacher education faculty benefit, as well, since "the fact that university faculty are no longer teaching [only] on the university campus, and what they say will be validated in the classroom the next day, keeps everyone on their toes. "

In Texas, the time students spend in K-12 classrooms before they receive their teaching degrees is uniquely styled, in large part, because of efforts by the Texas Education Agency to reform teacher education. The Texas Education Agency (TEA) is a unit of the Texas state government, with extensive responsibilities for K-1 2 education and a serious commitment to technology use. The TEA oversees the certification of teachers and allocation of state funds to 1,050 local school districts with more than 6,000 schools. The TEA also supports 20 Regional Education Service Centers that provide direct services to the districts in their region (see chapter 4).

Since the 1970s, when personal computers became affordable, there has been interest at TEA in the use of technology in schools. The 1988 publication of TEA's "Long-Range Plan for Technology" makes a case for technology as one means of improving education in the state. Among the plan's initiatives that required action on the part of the state's legislature was a call for the Texas legislature to appropriate $50 per year per public school pupil for technology, with annual increases. The legislature actually appropriated $30 per year per pupil in 1992-93, and the figure has not been increased; however, it amounts to a commitment by the state of $113 million annually for technology.[1]

[1] The only significant restriction is the requirement that districts spend at least 75 percent of the money on "instruction, " as opposed to hardware TEA encourages districts to spend 30 percent of their technology allocations on staff development, but thus is a recommendation, not a requirement

BOX 5-3 (cont'd.): Redefining Preservice, Texas Style

This history of support for technology in schools has evolved into support for better use of technology in the preparation of new teachers It became clear that if K-12 students have technology access and experience, so, too, should the new teachers who are entering the classroom. The evolution to preservice support, however, has come about on a winding road. In 1987, the Texas legislature eliminated the undergraduate degree in educatihon and required that all students preparing to be teachers have a content major. The legislation also limited the number of courses a student could be required to take in education to 18 semester hours—12 credit hours of professional coursework and six credit hours for student teaching. Also in the 1980s, TEA developed (with legislative support) alternative certification programs, so college graduates who had no teacher education courses could become certified to teach while working as teachers.

By the end of the 1980s, it was obvious that both the 18-hour rule and alternative certification were not the optimal solutions. Alternative certification programs amounted to a sink-or-swim situation for the new teachers, and teacher education programs, while shorter, still emphasized lecture-based courses removed from the classrooms. Furthermore, there was concern that new teachers were not being prepared to use technology.

Ultimately, TEA developed an alternative to traditional university-based teacher education and alternative certification, and in 1991 legislation was passed authorizing funding for Centers for Professional Development and Technology. Approximately $34 million has been invested to support the restructuring of new teacher education programs through CPDTs. For the past three years, planning grants were awarded to teacher education programs in public and private colleges and universities to develop plans for reforming teacher education, CPDTs, like the one described in the above scenario, have an emphasis on integrating technology throughout the preservice curriculum and inservice staff development plan. This led to the creation of professional development schools—that is, sites within the K-12 setting that theoretically afford preservice students the best of both worlds, learning about teaching as teacher candidates and gaining important teaching experience in real school settings.

The responsibility for effectively Integrating technology into the new teacher education programs rests not with TEA but with the programs. So far, 17 collaborative have been funded for CPDTs, This number includes 50 percent of the educator preparation programs in Texas. Quantitative data indicate students going through a CPDT program score higher on the state-administered ExCept exam.[2] The support of the state education agency and the state's legislature for technology as a primary emphasis in teacher education reform provide a valuable example for other states to consider.

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[2] The ExCept exam is required both in subject specialty and the general component prior to receiving certification to teach in Texas,

SOURCE John Mergendoller et al , "Exemplary Approaches to Training Teachers To Use Technology, " OTA contractor report, September 1994, pp. 9,1-930

Overall, teacher education Programs in the United States do not prepare graduates to use technologyas a teaching tool, and recent graduates of teacher education programs say they do not feel wall prepared to use teachnology in the classroom.

take, and as they move to abolish the undergraduate degree in education.

A recent survey at the University of Southern California indicates that-across all areas-"only a small percentage of college courses and classes use technology to enhance or supplement instruction."[62] According to the study, roughly one college course in six uses computer labs, and only one in 10 uses computer-based simulations and software. The survey also reports that research universities are more likely than other types of institutions of higher education to consider resources such as the Internet to be important for access to content that otherwise might not be available for classroom instruction.[63]

Technology Preparation in Colleges of Education

Even if the courses prospective teachers take in the general studies programs do not necessarily model technology use, it is appropriate that schools and colleges of education do so. However, anecdotal evidence, surveys conducted for OTA,[64] and a number of other sources[65] suggest that this is not so. **OTA finds that overall teacher education programs in the United States do not prepare graduates to use technology as a teaching tool.** For example, although the majority of colleges of education surveyed offer a course in information technology (educational computing, educational media, or instructional technology), only slightly more than half require that their students take such a course.[66]

For most types of technology,67 faculty who responded to the OTA contractor survey reported very low levels of use in the COE classroom, and recent graduates reported even lower levels of exposure to technology. In addition, the majority of teacher education faculty surveyed do not model technology use, do not use information technology to accomplish the objectives in the courses they teach, and do not teach students how to use technology for instructional purposes.

[62] *The Heller Report,* vol. 6, No. 3, January 1995, p. 1,7.

[63] Ibid.

64 Much of this section comes from Jerry Willis et al., "Information Technology in Teacher Education: Surveys of the Current Status," OT contractor report, March 1994.

65 See, e.g., R.E. Schumaker and P.G. Hossain, "Computer Use in Education: Faculty Perception and Use of a Computer Learning Center," *Journal of Computer Based Instruction,* vol. 17, No. 3,1990, pp. 87-90; and J. Fratianni, R. Decker, and B. Koven-Baum "Technology: Are Future Teachers Being Prepared for the 21st Century?'' *Journal of Computing in Teacher Education,* vol. 6, No. 4, pp. 15-23.

[66] Likewise, a separate study of teacher education programs in Michigfan found that 95 percent offered some type of training in information technology for teacher education students--but not necessarily a couse--and that 40 percent required information technology training of students in the teacher education programs. L. Carr, D. Novak, and C. Berger, "Integrating Technology into Preservice Education: Determining the Necessary Resources,'' Journal of Computing in Teacher Education, vol. 9, No. 1, pp. 20-24.

[67] See definition of *technology* as used in chapter 2 of this report.

When the OTA contractor survey asked recent graduates how well their teacher education program prepared them to use technology in their teaching, the majority responded that they did not feel they were prepared. As one respondent said, "Training is definitely needed in teacher education programs on things such as Hypercard, multimedia, CD-ROM, etc. The class I had showed us slides of what could be done, but we really gained no understanding and received no training in these areas."[68] **One conclusion to be drawn is that telling students about what is possible is not enough; they must see technology used by their instructors, observe uses of technological tools in classrooms, and practice teaching with technologies themselves if they are to use these tools effectively in their own teaching.** As a recent graduate stated, "most colleges and universities are using a broad base of computer technology; however, they are not giving student teachers enough background to use this in their own classrooms."[69]

In those COEs where technology is an integral part of teacher preparation programs, anecdotal evidence suggests that students will adopt the use of educational technology in instruction if they see faculty members modeling technology use.[70]

The low level of technology coverage in teacher education contrasts with the way that other professional preparation programs address relevant technologies. For example, few health care professionals complete their training and enter practice without an understanding of the technologies used in their specialty. Few business college graduates complete their degrees without experience using the computer-based tools of their business specialties. Of course, professions such as these often require graduate study, so students in those programs may have more extensive exposure to the school's resources, including technologies. Most teachers only need to complete an undergraduate program to teach, and the data reported here suggest that most new teachers graduate with limited experiences or understanding of the ways technologies can be used in their professional practice—the classroom.

Methods of Teaching With and About Technology

Coverage of technology in teacher education can be divided roughly into three types: 1) *discussion/demonstration,* 2) *technology practice*, and 3) *professional practice*. A faculty member conducting a science teaching methods course might, for example, *discuss* how computer-based simulations could be used in a high school science class. The instructor might even *demonstrate* a few simulations for the class using a large monitor or projection panel. This occasionally occurs in teacher education, but it is rare.

The next level of engagement with technology involves hands-on *technology practice.* In the science methods course, for example, the instructor might take the students to a teacher education computer lab and have them install science simulations into the computer and examine how they work.

At the third and most critical level of engagement, *professional practice*, students in the science methods class might see simulations being used in a high school chemistry or physics class. They might visit a classroom, view a classroom via a television connection, or watch it from a videodisc or videotape. At the level of professional practice, these students would also *practice teaching with technology.* In the methods course, they might create lesson plans that include technology and practice in teaching exercises. Later, in student teaching, they would observe teachers using technology and then teach with technology themselves.

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[68] Willis et al., op cit., footnote 64, p. 121.

[69] Ibid.

[70] Mergendoller et al., op. cit., footnote 61.

The opportunity for preservice teachers to practice teaching with technology is not common in colleges of education. However, Trina Dendy (right) conducted a distance-learning course for high school students as part ofher student teaching experience. Here, students in Corinth, Mississippi, receive the lesson (lefr), which she broadcast from West Point, miles away

In the contractor survey of recent graduates, 40 percent said education faculty used technology in the courses they completed; specifically, more than 60 percent said they had been *taught with* or *taught to use* some form of technology. However, an analysis of this is revealing: the areas that were most often reported as "taught about" were drill-and-practice applications and word processing. While half **of recent graduates surveyed reported being prepared to teach with drill and practice, tutorials, games, and writing and publishing centers, less than one in 10 felt they could use such formats as multimedia packages, electronic presentations, collaborations over networks, or problem-solving software. Rarely were** teacher education students asked to develop material or create lessons with technology.

When technology topics are included, they are more often discussed, read about or demonstrated than modeled, used, or incorporated into lessons created by students. When considering the integration of technology into specific content areas, the survey suggests that the majority of faculty did not require students to use technology, to develop materials, orccreate lessons using technology. Only the videocassette recorder was used by more than 20 percent of teacher education faculty, and only word processing was cited by more than 10 percent of faculty as a basis for creating lessons. Part of the reason technology is not used more by faculty, according to one survey respondent, may be that "until we train [COE] teachers and provide teachers with equipment, the teachers are not going to do much with students." [71]

Student Teaching and Technology

Technology does not appear to play a significant role in student teaching assignments. Even in preservice programs where technology is prev-

[71] Ibid.

alent and integrated in an exemplary way, one of the consistent problems identified in the survey and the OTA case studies was the lack of student teaching placements in technology-rich classrooms with teachers who know how to exploit the possibilities afforded by technology. Often, the preservice teachers knew more about technology use—in general, not specifically for education—than the practicing teachers supervising them.[72]

Barriers to Technology Use in Colleges of Education

Barriers to more integrated use of technology in COEs are similar to those in K-12 institutions. When asked to rank a list of 19 potential barriers, COE faculty gave the highest rankings to time, limited resources, faculty comfort level and attitudes, and little institutional encouragement for technology use. However, COE faculty do not generally see either complexity or reliability of equipment as major barriers to wider use of technology, and they see themselves as competent to use technology.[73]

Access to Resources

The data from the OTA survey suggest that a typical college of education is more likely to be a "have not" than a "have" when it comes to many types of educational technology. This is a serious barrier, since access to resources is an essential element of any effort to increase both teaching *with* and teaching *about* information technology.

Hardware and software resources are a problem in many programs. One suggestion—although only part of the solution—is a massive infusion of equipment through grants from computer companies (see box 5-4), the federal government, or states. However, funds for the acquisition of up-to-date hardware and software have been difficult for COEs to secure. As noted in chapter 6, federal support for technology in COEs has been limited.[74] The problem is also one of "pecking order" within a university. As one educator pointed out, "Colleges of education are often at the very bottom of their universities' priority lists for equipment funding, despite the fact that, in many instances, the college of education might generate the largest number of student credit hours (and therefore revenue) for the university."[75]

Information collected through the OTA case studies of four teacher preparation programs suggests that many colleges of education have so little equipment that any effort to increase technology presence in coursework would overwhelm existing resources. In addition, there is a tendency in education to think of technology as just another capital cost, to be amortized over 10 or 15 years. Given the rapid pace of technological innovations—and the reality that new software releases most likely will not run on machines more than four or five years old—this assumption is incorrect. Technology is not a one-time expense. As hardware and network installations become more technically complex, they need more attention and maintenance—costs that the COEs must consider and create long-term plans to handle.[76]

COEs, like K-12 schools, need to plan for how technology will be distributed and used before mandating its use. Trying to successfully implement hardware and software without a plan outlining the needs and functions to be addressed by that technology places the cart ahead of the horse. For example, buying 20 computers with built-in CD-ROM drives does little to define what will be done with them or how they could be deployed in a teacher education program. The machines could

[72] Mergendoller et al., op. cit., footnote 61.

[73] Willis et al., op. cit., footnote 64.

[74] In contrast, for example, teacher education programs in the United Kingdom were recently invited to write proposals for how they would use computer-controlled CD-ROM equipment; the proposals were evaluated by the government's education authority and most were funded.

[75] Paul Resta, "Preservice Education," *The Electronic School* (Alexandria, VA: NSBA, September 1993), p. A28.

[76] Mergendoller et al., op. cit., footnote 61.

BOX 5-4: Beyond the Box: Why Preservice Integration Requires Full Support

Working from a belief that improving technology use in K-12 education required improving the way new teachers learn to use technology, in 1989 IBM initiated the Teacher Preparation with Technology Grant Program. The program's primary goal was to help integrate technology into the curricula of teacher preparation programs nationwide, and secondarily, to introduce more K-12 teachers, present and future, to MS-DOS-based computer technology.

The effort was substantial: based on proposals submitted to IBM, a total of $30 million was donated (in hardware, software, cash, and training) to 144 teacher preparation institutions across the country. Each site received virtually the same equipment to establish a networked IBM lab.[1] An evaluation of the program reported that, over a three-year period (1990-93), approximately 52,000 preservice teachers have been trained on the equipment in the labs.[2]

One commonly voiced concern about such integration efforts in colleges of education is whether the necessary levels of technical and other support are sufficient to enable a critical mass of college of education faculty--+ specially those who are not currently technology advocates—to become technology users, The IBM evaluation study found that nearly two-thirds of the teacher preparation faculty involved in the projects were trained to use the equipment; however, less than half received this training as a result of the grant program.[3]

In their grant applications, most sites proposed using the equipment for training preservice and inservice teachers and developing curriculum materials for integrating technology in instruction; however, arrangements on how this was to be done was left to the grantees. Ultimately, the open-ended nature of the grants proved to be a problem for many sites. While they received a great deal of technology, the training and support given to sites was more technical "nuts and bolts" for getting the labs up and running rather than in training the teachers to effectively integrate technology in their classrooms. The evaluation reported, "sites felt that additional training for faculty was necessary" and suggested that supplemental funding should have been targeted for this training. During the grant award process, as one site pointed out, IBM could have "forced the colleges of education to provide . release time, or other perks as compensation for learning the technology. IBM had the clout to require this, they just didn't know it. "[4]

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[1]Most sites received 10 to 15 IBM Model 25 or Model 30 workstations, a PS/2 Model 80 file server, two printers, networking hardware and software, IBM courseware, a $5,000 cash grant, training for two project staff in Atlanta, and technical support

[2]Gary G Bitter and Brandt W. Pryor, *The National Study of IBM's Teacher Preparation with Technology Grant Program,* Arizona State University, Technology Based Learning and Research (Tempe, AZ Arizona State University, 1994), p. 13

[3]Ibid , p. 11.

[4]Ibid,, p. 21,

be placed in a lab where teacher education students learn word processing. Or, three or four could be put in each of the college classrooms where methods courses (e.g., science, reading/ language arts, mathematics, art, social studies) are taught. However, if several of the science education faculty want to begin teaching students how to use videodisc-based packages that supplement or replace textbooks in some science classrooms, they might need fewer computers with CD-ROM capabilities and more videodisc players with bar code readers. Another alternative would be to put the computers in the classrooms of cooperating teachers in the schools—those who had been encouraged and supported based on a plan identifying their technology needs—as they supervise student teachers.

BOX 5-4 (cont'd.): Beyond the Box: Why Preservice Integration Requires Full Support

The IBM program evaluation found that about two-thirds of respondents noted positive changes in the teacher preparation faculty's attitudes toward the computer lab. For example, one site responded that, "The easy access to the network encouraged the faculty to try to integrate [the] technology into their classes and helped them see the value of a computer network in the learning and teaching process,"[5] A total of 367 courses—both required and electives—were developed or revised to incorporate the computer technology.[6]

Also, over half the sites reported that they included local schools as part of their projects, most often through involvement with inservice teachers, bringing children to the site lab, and through activities conducted as a part of the preservice program. Several sites maintain that much of their implementation success was due to the participation of and interaction with the local schools. As one site reported, "Participating in the schools gave [technology integration] a reality that was invaluable for the education faculty. The school's support of technology prods the university faculty and administration to do the same. "[7]

Although educators at the IBM sites appreciated the good intentions shown by IBM, many were frustrated by difficulties in integrating the technology into teacher preparation curricula, suggesting lessons for similar efforts. Some of the problems reported include technical or equipment difficulties, lack of training and technical support, lack of resources, outdated hardware (most were 286 machines), and marginal software. Some sites were able to resolve these problems, but many were not.

The IBM grant program evaluation suggests that an infusion of technology into a program is not sufficient to produce change. The open-ended nature of the grant program was a detriment to success for many of the sites. Sites were allowed near total discretion on how they integrated the grant into their teacher preparation programs; many sites were frustrated by a lack of guidance and support Recommendations made to IBM by the grantees suggest that more direction was needed. "[IBM should] have a clear set of expectations of what the grant recipients are to do" and' "have a reasonably well-developed game plan-don't do this in a vacuum. "

[5] Ibid., p, 47.

[6] The grant sites reported that 84 new courses were created and 283 existing courses were revised to incorporate the IBM technology.

[7] Bitter and Pryor, op. cit., footnote 2, p 7.

SOURCE. Gary G. Bitter and Brandt W. Pryor, The *National Study of IBM's Teacher Preparation with Technology Grant Program* (Tempe, AZ Arizona State University, 1994).

Faculty Comfort Level, Attitudes, and Training

Technology planning in the COE should involve a wide range of faculty from the college. One problem, however, is that many faculty do not have the knowledge needed to make informed decisions on technology issues, according to the aforementioned survey. Furthermore, professional development for faculty tends to emphasize the fundamentals of computing rather than the integration of technology into education. Like K- 12 educators, COE faculty need to understand ways technology can enhance instruction in their specialty areas.

A potential barrier to technology use in COES may be the attitudes of faculty. Although most teacher education faculty believe that technology is an important aspect of both K-12 education and teacher education, many seem to view technology as a separate type of content, rather than as something that should or could be integrated into a content area such as a math course or a social studies methods class.[77] **It is not surprising that faculty members agree technology is important while simultaneously presuming it is a "topic" that will be covered somewhere in the curricula other than in the courses they teach.**

OTA's data suggest most teacher education faculty concur that technology will play a critical role in the future of both education and teacher education. That generally positive attitude, however, does not translate into specific plans and actions the individual faculty member implements. There are several reasons for this dichotomy. While faculty say technology is important, many do not feel comfortable using technology in the COE classroom. That is true even though the majority of faculty (86 percent in the OTA survey) use a computer at home for many hours a week. Although they may have basic proficiency with word processing, disk operating systems, and spreadsheets, many are not as comfortable when it comes to integrating computer technology into instruction. In fact, most COE faculty in the OTA survey report some anxiety in using technology with their teaching applications, and almost all (90 percent) consider the knowledge level and confidence level of teacher educators to be barriers to wider use of information technology in teacher education. **Since the majority of teacher education faculty completed graduate programs and taught in schools where technology was not a major part of the educational environment, it is not surprising that they tend to have limited experience with technologies for instruction.**

Teacher educators responding to the OTA survey reported that they need help in integrating technology experiences into the courses they teach. A major effort to infuse technology into teacher education would include workshops, seminars, publications, and support materials developed specifically for various areas of teacher education.

Another attitudinal barrier among many teacher education faculty is a tendency to separate information technology from other components of the program such as subject matter content and professional practice skills. A methods instructor, for example, who is teaching cooperative learning strategies, may view information technology as a topic competing for time in his or her curriculum rather than as an integral part of effective cooperative learning strategies in the classroom. The tendency to isolate information technology, to put it in a separate "technology ghetto" in the teacher education curriculum, may be a major impediment to integration across the curriculum. The problem is comparable to teaching writing: are writing skills to be taught only by the English faculty, or is it something all instructors should take into consideration?

Another factor that influences faculty comfort level with technology is the perceived match between technological applications and the theoretical perspective of the faculty member. Some uses of technology in teacher education, such as drill-and-practice software, are based on a behavioral model, while others, such as interactive, multimedia models, are based on a cognitive or constructivist theory. Staff development and support efforts should take theoretical perspective into account and work with faculty within their preferred theoretical mode, unless an additional goal is to change underlying theory as well as encourage technology use. Researchers suggest both actions—increasing technology use and changing pedagogical theory—can happen hand-in-hand.[78]

Staff and Institutional Support

Faculty in colleges of education, like K-12 educators, feel they need more staff support for technology; however, unlike those in K-12 settings, they

[77] Willis et al., op. cit., footnote 64.

[78] Barbara Means (ed.), *Technology and Education Reform* (San Francisco, CA: Jossey-Bass Publishers, 1994).

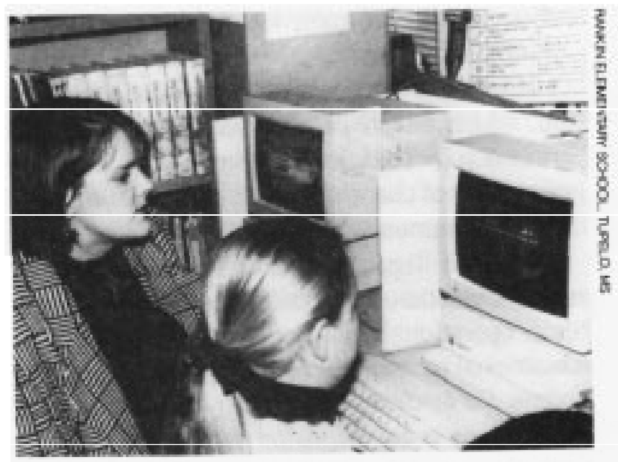
are more likely to have some technical support staff available in their institutions. Half the faculty responding to the OTA survey said their college had a full-time computer lab manager, and over one-third said a full-time technician was available. Unlike K-12 schools, additional support in COEs can be provided by graduate students who are comfortable with technology.

Another potentially important barrier to technology use in COEs is lack of institutional support for technology use by faculty. Although the incentive system in institutions of higher education is different than in K-12 schools, these rewards (e.g., tenure, merit pay, or promotions) do not encourage COE faculty to develop curricular innovations, software, or other information technology applications. As one respondent said,

> At a major university, rewards come only to those who do research and writing. No time is available to retool (learn the necessary skills) and restructure classes accordingly. It's an exciting time in the development of more advanced instructional technology. Released time for hands-on information immersion would be exciting.[79]

Only one-third of the faculty responding to the OTA survey said there were rewards for investing time in developing technology-based instructional materials or educational software instead of conducting more traditional research activities. About 40 percent of the faculty felt that the generally low level of interest demonstrated by colleges or institutional leadership was an important problem; only one in four did not see it as a barrier.

It seems that, in general, the use of computer-related technology as a teaching and learning medium is employed much less in teacher education than would be expected, given what is being taught about its value to education in technology-related teacher education courses. The opportunity for preservice teachers to experience models of computer-supported instruction before they try to manage it themselves is seldom available, suggesting the lack of synergy between computer education specialists and mainstream teacher education faculty.[80]



Finding enough student teaching placements with enthusiastic, expert technology-using teachers is a challenge for many colleges of education, but it is a key to preparing a generation of teachers who are fearless with technology

MODELS OF CHANGE: LESSONS FOR THE FIELD[81]

What the survey data do not tell are the stories of COES where changes have occurred and continue to take place, creating models for the field. There are colleges of education where technological tools are being implemented in ways that overcome some of the barriers of access, attitudes, training, and support discussed earlier in this chapter. These institutions, where technology support has been an intrinsic part of the vision of the teacher education program, share certain characteristics, including a required course that teaches students how to use technology, exposure to technology -rich K-12 classroom environments,

[79] Willis et al., op cit., footnote 64, p. 89.

[80] Betty Collis,"A Reflection on the Relationship Between Technology and Teacher Educatin: Synergy or Separate Entities?'' *Journal of Information Technology for Teacher Education,* vol. 3, No. 1,1994, pp. 7-23.

[81] **The information in this section is excerpted, in large** part, from **Mergendoller** et al., op. **cit., footnote** 61.

and strategies that make technology transparent and intuitive to use.[82] In these institutions a number of factors come together: institutional leadership, which translates into funding support and permission for faculty to explore new areas; collegial support of changes; and close interaction with the K-12 community the COEs are meant to serve.

Even in colleges of education that might serve as implementation "models" for others—where basic operational knowledge of computer and educational technologies is acknowledged as important for students and faculty alike—this emphasis alone is not the vision driving the schools' technology training and support. Instead, what drives the use of technology is a vision of how educational technologies can solve instructional problems and provide curricular and administrative opportunities that could not be achieved as efficiently or powerfully otherwise. In such instances—including the four colleges of education highlighted below—technology is not embraced "because it's there," but because it is perceived to do important things better, more interestingly, or in entirely new ways.

University of Virginia, Curry School of Education

The elementary school computer lab is crowded with 4th-grade students and their "teachers"—preservice education students from the Curry School of Education at the University of Virginia (UVA). Pairs of eyes focus on computer screens as elementary and university students work together to explore the possibilities of the software program KidPix. *Movement is confined to wrists and fingers. Mouses click softly. Conversations are serious and focused. After struggling a while, a UVA student asks his 4th-grade partner if they should ask for help. "Yeah, it's time," comes the unenthusiastic reply. They lean over to the 4th-grader sitting next to them. "How can we save this under another name?" they ask. "We want to use it as a starting point for another drawing." The neighboring 4th-grader reaches over, takes possession of the mouse, and demonstrates how to solve the problem.*

At the University of Virginia's Curry School of Education, technology has been identified as one of the major strands within the teacher education program, and it is interwoven throughout the courses students complete as they work toward their degree. As part of this agenda, technology partnerships have been established with local schools to provide interesting and challenging field experiences for teacher education students, and simultaneously, to enrich the technological expertise of K-12 teachers. In addition, a statewide telecommunications system has been integrated with the teacher preparation course sequence and with the daily work of practicing teachers.

At its basic level, technology in the teacher education program at the Curry School involves three approaches to integration. First, the Curry School requires students to either take self-contained computer courses or demonstrate competencies in specific areas covered in those courses. Second, the college encourages the methods faculty to incorporate educational technologies into methods courses so students will have the opportunity to observe and practice teaching methods involving technology use. And finally, the school funds student teaching placements with teachers who use technology in their daily work.

There are, of course, challenges to these approaches. Computer courses do not address individual curriculum areas and can perpetuate the sense that technology is a separate topic, isolated from instruction. Expecting methods instructors to include technology in their courses raises questions of technological interest and expertise among those faculty. And finding enough student teaching placements where teachers are enthusiastic and frequent technology users is difficult.

[82] Mergendoller et al., op. cit., footnote 61.

The Curry School addresses these challenges through a schoolwide culture of technology use. This is reflected in several key factors, including support from the top by the dean, developing the technology expertise of faculty to serve as role models and provide support for their colleagues, creating technology-focused field experiences, and maintaining communications through a statewide telecommunications network.

The Dean's Role

The dean's support of educational technology infusion into the Curry School and the teacher education program is one of the reasons why Curry has developed a solid reputation for integrating technology and teacher education. When asked about the technology focus, given all of the ways one could support a teacher education program, the dean said he recognized "the power of technology to improve teaching."

> Technology could enable teachers to make a difference, and I felt we had to help those learning to be teachers to become competent technology users. I also saw, from a practical point of view, that you had to get ahead of the curve and stay ahead of the curve if you were going to distinguish yourself as an institution. This meant we had to make an early and substantial investment in technology if it was going to make a difference. Also, technology is very exciting! Teacher education is kind of a stodgy discipline, and I thought technology would liven it up. Finally, I thought that making technology available to Curry School students would raise the status of teacher education. Our students would be getting something Arts and Sciences students didn't. When we got our first IBM classroom installed, faculty from the engineering school across the street came over to admire it. They didn't have anything like it![83]

The dean's support of technology is more than rhetorical; technology integration is funded from the budget of the Curry School, and discretionary funds make possible small grants to individual faculty members or departments for technology purchases so that any faculty member who says he or she needs a computer gets one. Furthermore, the dean and other staff have been aggressive in competing for technology funds available to all of the schools within the university. The Curry School has received more than $2 million in funding from IBM, Apple, the National Science Foundation, and local telecommunications companies.

Developing Role Models for Faculty Technology Expertise

Using key faculty as role models for others is an important element in integrating technology across the college of education. At Curry, much of the initiative began with a faculty member[84] who was originally a member of the communications science program. His interest in and advocacy of computers and other educational technology have been critical in creating an educational climate that encourages Curry School teachers to experiment with educational technology and explore how technology can further their instructional and professional goals. His approach is one of patience, and his time frame long-term:

> You need to think in a five- to 15-year time frame. It takes that long. You have to work with one faculty member at a time. You keep coming around and find something they're really interested in. Everybody is not ready to swallow technology in exactly the same way at the same time. People are very reasonable; they will use technology if it makes sense to them.

[83] James Cooper was Dean of the Curry School of Education, University of Virginia, at the time of the OTA case study; he resigned from this position to return to teaching at the end of the 1993-94 school year. Information taken from personal communication, Feb. 3, 1994, Charlottesville, VA. Mergendoller et al., op. cit., footnote 61.

[84] Glen L. Bull, Professor of Instructional Technology, Curry School of Education, University of Virginia.

> You have to remember that technology has layers. There's the technological, and that is what everybody focuses on. But there's also the social and the institutional. Here you have to go one person at a time. You can't just have one or two stars and leave everybody else behind. The minute you define supporting the stars as your mission, you are lost. It's a nibbling away process. The key is not to try to convince the faculty but to let them hold their views. Make sure you include everybody—support both Mac and DOS platforms.[85]

Currently about 20 percent of Curry School faculty use some form of instructional technology as a research focus, another 20 percent use it extensively in their teaching to access and display information, and the remaining 60 percent limit their technology use to word processing and other personal productivity uses. One faculty member has been given time to work with the less technologically proficient faculty on the instructional uses of technology. A conference room with four networked computers (Macintosh and MS-DOS) has been set aside to provide for "walk-in" faculty consulting and development. Although graduate students have provided similar services in the past, this is the first time a faculty member has been assigned this role. While the arrangement is now a pilot program, if successful, it may become part of the Curry School's faculty development and support structure.

There is also an Educational Technology Committee, with one representative from each department in the Curry School. Now in its 10th year, the committee meets twice a month in meetings open to all faculty who wish to attend. The committee is responsible for identifying the overall technological direction to be taken by the Curry School, but it also serves as a technical and emotional support group. One member explained, "When I need to know something, when I need to know where to go, I find out here."

Technology Field Experiences

Over the last several years, the Curry School has embarked on a number of pilot projects to enable its students to use technology in their field experiences with K-12 teachers and students. For example, in the spring of 1993, an after-school computer club was created to pair third-year teacher education students with a socioeconomically and ethnically diverse group of 4th-grade pupils at a local elementary school. The club—which meets once a week in a computer lab at the school—enables the elementary students and supervising lab teachers to gain computer skills and build self-confidence, while the Curry School students acquire the practical experience working one-on-one with students. When the club meetings conclude, the Curry students return to the classroom and write reports to "their" students' classroom teacher, make notes in a journal about the tutoring experience, and plan activities for the following week's meeting.

Another pilot project is the Technology Infusion Program, pairing Curry School students with practicing teachers. The Curry students take a fifth-year course in instructional computing, surveying a range of instructional concepts. During the first half of the semester—after learning about a technology concept or software program—students try out "mini-projects" in a practicing teacher's classroom. The focus of the class then shifts from learning a skill to practicing it. Later, Curry students work on a more elaborate project with the teacher. Currently, to ensure success in the Technology Infusion Program, the number of participating Curry School students is limited to 20 a year.[86] Part of the reason for this is that the Curry

[85] Glen L. Bull, personal communication, Feb. 4, 1994, as cited in Mergendoller et al., op. cit., footnote 61.

[86] Although the overall enrollment at Curry is approximately 1,300 students, the majority of these are pursuing advanced degrees. The teacher education program is a five-year program, with approximately 100 students each year entering the program in their sophomore year.

staff are aware that small-scale success generates a momentum for expansion, and expansion can often overwhelm resources allocated to a project. As one professor says, "We're guinea pigs—or, better yet, canaries going down the mine. You have to go in very small steps . . . build on what has gone before."[87]

Virginia's PEN

The Virginia Public Education Network (Virginia's PEN) directly serves Curry School students. Virginia's PEN is a distributed network that began in the mid-1980s as Teacher-Link, a network connecting the teachers supervising Curry School student teachers, and the student teachers themselves with the Curry School faculty.[88] It also provided participating public schools with access to the Internet. Today, the network is the literal and figurative backbone to educational telecommunications in Virginia. As of 1994, Virginia's PEN connected 2,000 public schools in 137 districts to the Internet, providing a seamless telecomputing network that links (via a toll-free number) all Virginia schools from kindergarten through graduate school.

While Virginia's PEN duplicates some communications and conferencing services often provided by commercial networks, such as America Online, it also provides services designed specifically for K-12 teachers. The services are organized by "pavilions," and each pavilion has its own moderated conference, projects, and listings of instructional and staff development resources by subject area. Students communicate with each other, Curry School faculty and staff, and K-12 teachers to discuss projects and problems, and present solutions. The result is an extended Jeffersonian academic village[89] online, connecting Curry students, K-12 teachers, and Curry faculty.

Lessons Learned[90]

A number of important lessons can be culled from the experiences at the Curry School:

- **Rather than mandating the use of educational technology, look for pockets of opportunity and exploit them.** The culture of technology use is built on a social foundation. Helping individuals to work more effectively by introducing them to appropriate technology will secure their general support of technology use and establish a critical mass of users. The expectations of this critical mass will encourage the growth of a technology-using culture within the school.
- **Preparing preservice teachers and their professors to use technology takes a long time.** It is essential to maintain a realistic time frame of at least three to five years.
- **When introducing a technological innovation, go slow.** Too slow is preferable to too fast. New technology is inherently "buggy"; plan an implementation schedule that allows enough time to work out problems.
- **Focus on the current experience and needs of the individual technology user.** Preservice teachers and faculty vary in their technological expertise and anxiety. Necessary training time will vary. Adequate time must be provided to support the technophobic as well as the "techies."
- **Educational technology infusion needs to be an interdepartmental endeavor.** By involv-

[87] Bull, op. cit., footnote 85.

[88] Funding was provided by the Curry School, IBM Academic Information Systems, and the Centel telephone company. At the time it was created, the network was known as Teacher-Link and, in addition to communications for teachers, it gave participating public schools access to the Internet. By the end of the decade, the Virginia Department of Education agreed to institutionalize it statewide.

[89] Thomas Jefferson, President of the United States, founder of the U.S. Patent Office and supporter of innovation, also founded and designed the University of Virginia to extend his own vision of an "academical village."

[90] These and the lessons learned in subsequent sections are based on the analysis of the OTA contractors' observations and extensive discussions with the faculty at the various schools.

ing faculty from all program areas, and making decisions about technology purchases an interdepartmental undertaking, turf wars over technology can be minimized.

- **Technology replacement and upgrade costs should be included as a regular line item in the operating budget.** While special grants can increase hardware and software, consistent long-term support is needed.

University of Wyoming, College of Education

Wyoming has developed an impressive, well-articulated plan to enhance the technological capabilities of present and future teachers and the K-12 students they serve. In the late 1980s, the public schools and the university developed a new model for teacher education in which each sector would play a role in educating students and teachers about technology. The university's college of education would infuse technology experiences throughout a redesigned teacher preparation program. The districts would provide placements for aspiring teachers where they could receive hands-on experience and also be exposed to some classrooms that were not so "computer-rich."

The support for Wyoming's program stems from the bottom-up manner in which the mandate for technology was developed. School reform was the vehicle for creating a plan that is designed to meet the overall needs of education throughout the state. Computer skills, specifically, were seen as integral to children becoming productive citizens. There is a strong commitment to improve the technological skills of teachers, both preservice and inservice, that is shared by individual school districts, the state department of education, and the University of Wyoming.

The College of Education at the University of Wyoming is a pioneer in the use of several information technologies that have promise for extending the reach of a university and for interconnecting school districts in useful ways. These technologies include interactive compressed video, audio teleconferencing, and electronic mail on the Internet.

The University of Wyoming is the only four-year teacher education institution in Wyoming—a huge state with its population distributed in small towns and rural pockets at great distances from one another. As a result, outreach has always been a priority for the university, and the college of education in particular. Many inservice courses are offered through extension, and there is a large item in the school's budget to cover the cost of car and air transportation for faculty who teach these courses. But extension teaching in a sparsely populated northern state is difficult for a number of reasons. The distance problem is not only one of transporting faculty to a distant site, but of having sufficient students in any one location to justify offering a course. In a given semester, there may be only a few teachers or administrators in any one town who need a particular course. In addition, for five months of the year there are unpredictable and often severe snowstorms that make travel treacherous and make it difficult to bring any group together on a regular basis. Because of the challenges created by distance, technology has become a necessity, not an extra.

Linking Schools to the University with ICV

In 1990, when the governor announced the availability of monies from an education trust fund and invited proposals, several educational groups joined forces and responded. The university's School of Extended Studies, the College of Education, the state Department of Education, and a number of public school districts were all interested in two-way interactive video communication. The state Telecommunication Office proposed the creation of a telephone network capable of supporting interactive compressed video (ICV) by using the excess capacity of the existing state Data Network Backbone. ICV is a form of television transmission that requires less sophisticated equipment than typical broadcast television. Unlike one-way broadcast television, ICV supports groups at two or more sites interacting with one another. This technology would make it possible to overcome the long distances that separated the districts from the university and from one another. It would facilitate both inservice training of existing teachers and mentoring of preservice teachers in their district placements.

Student teaching placements are part of Wyoming's "Phase Program," begun in 1992, in which teacher education students pass through three phases of increasingly intense clinical involvement in schools around the state. For students who choose a career in teaching early in their undergraduate career, four out of eight semesters that comprise their undergraduate degree program include placements in K-12 schools. Each phase has clearly stated expectations for the technological proficiencies students must exhibit at the end of the phase. By the end of the program, each student should meet the college's new requirements for technological competencies.

Together, the public schools and the university developed a new model for teacher education in which each plays a role in educating students and teachers about technology. The districts provide placements for aspiring teachers where they can receive hands-on experience with some of the best model programs and also be exposed to the realities of the less computer-rich classrooms. The placements are in model schools, called Centers for Teaching and Learning (CTLs). A CTL is a school whose teachers and administrators have engaged in a lengthy process of renewal, examining its mission and redefining its curriculum and instructional approaches in ways that recognize this mission. Each CTL has identified master teachers to serve as mentors for university students assigned to the district. In addition, each district has identified Clinical Teachers, partially paid by the university, who supervise college students when they are present in the district.

This model would not be possible without technology. The interactive compressed video system is used to maintain a regular connection between the university and the district. Two or three times a month, the university and district hold electronic meetings where students give progress reports on their experiences and respond to teaching-learning issues posed by their university professors. District clinical teachers set the context and facilitate student reporting.

Another use of ICV is to support school renewal efforts around the state. Under project VEIN (Video Education Interactive Network), school-university teams develop seminars and courses to support various aspects of school restructuring and curriculum improvement. Although still new, ICV is being used experimentally in a variety of applications. For example, faculty in the college of education's counselor education program have set up a monthly "town meeting" where counselors in outlying districts can go online to share ideas about different issues. A difficult issue for Wyoming at present is trying to expand the ICV network, since costs for installing the interactive compressed video remain high.

The Role of a Laboratory School Within a College of Education

Laboratory schools—common in the past—are actual schools connected with colleges of education, where prospective teachers can gain much of their teaching experience. However, many COEs closed their lab schools in the 1950s and 1960s, in part, because the students in lab schools were traditionally the children of university faculty, and many were concerned that teacher candidates would not be exposed to a range of students in the lab schools.

Since then, many COEs have developed instead Professional Development Schools (PDS)—a public school outside the university but serving many of the same functions as previous lab schools. Wyoming has both these institutions: a series of Professional Development Schools that play an important role in educating future teachers about appropriate roles for technology, and a lab school located in the same building as the college of education. The lab school's proximity to the university and its technological advances combine to give it primacy among the professional development schools in Wyoming. There may be other schools in Wyoming equally advanced technologically, but they are at a great distance from the campus at Laramie. The Phase Plan is good for immersing education students in real schools; the ICV technology is promising for interconnecting

CTLs and the college of education; but the physical proximity of the PDS—coupled with the fact that the school's students can share resources with the college—makes it an unusually rich resource for learning about technology. Almost daily an education student might be sitting next to a middle school student who is using computers in interesting ways. When it comes to learning about technology—a rapidly changing field—Wyoming has found its laboratory school to be a valuable resource.

Lessons Learned

At the University of Wyoming College of Education, a number of lessons are directly related to the fact that Wyoming is in a unique geographic setting where vast distances and severe weather patterns often dictate schedules. There are general lessons to be shared, however:

- **Changes at the college of education that are embedded in public school reform will more likely have a long-standing impact on the way teachers are prepared.** Long-term change has a better chance of surviving if it is nurtured at the bottom and supported from the top, rather than being mandated from the top.
- **Informal learning communities can be created that involve technology at all levels and each level can assist the others to do their best.** In some cases, the K-12 students themselves learn the technology and help their teachers find ways to use it. Teacher education students placed in these settings learn that all expertise does not reside in the teacher, a valuable lesson.
- **A lab school within a college of education or a professional development school nearby may be an extremely valuable—and convenient—resource for teacher education students.** It can be a particularly useful testbed for new uses of technology.

University of Northern Iowa, College of Education

At the University of Northern Iowa (UNI), a professional development/laboratory school has also proved a unique asset, modeling technology use and utilizing remote video to bring classroom exposure to teacher education students. As in Wyoming, the lab school at UNI is to teaching what a research hospital is to a medical school. A recently installed fiberoptic network connects the lab school to the college of education, so faculty can "ship" classroom video to methods classes. This is part of a pilot project that allows video from any of the 48 classrooms at the lab school to be sent to classrooms in the college of education. Using a portable control unit that can be wheeled into classrooms, the model also relies on two professional-quality video cameras and several microphones in a classroom for transmission. (The transmission is also videotaped so it can be used later for anyone who misses it, or for reflection on teaching practices.) The lab school has its own technology committee that encourages diffusion of technology throughout the school.

Two video classrooms at UNI are also used for distance education courses. For example, if classroom teachers want to take additional classes so they can be certified to teach students with disabilities, the course is offered in the video classrooms with a UNI professor as part of the Iowa Communications Network (ICN). ICN is used by both education and state agencies.

Technology and Student Teaching

The entire state of Iowa has a population of around three million. The number of UNI students who do classroom observations and student teaching is far greater than the university's local area (with a population of about 100,000) can handle. With over 700 students to place in student teaching each year—and because many schools in Iowa are not culturally diverse—UNI places students throughout the state, and in other states and countries. There is, for example, a full-time UNI faculty member in San Antonio, Texas, where (in the spring of 1994) 28 UNI students did their student teaching in the diverse, multicultural local schools. Other UNI students have done student teaching in Nebraska, Kansas, Oklahoma, and Egypt.

To deal with hundreds of student teachers spread across the state and nation, UNI has organized students into clusters, 10 of which are in Iowa. The clusters are made up of all the student teachers in a region along with a UNI faculty member assigned to that region to support the students, the collaborating teachers, and other professionals, including the 85 members of the UNI Teaching Associates Cadre (a group of master teachers in Iowa schools who participate in collaborative projects including revising and improving student teaching experiences). UNI also funds a clinical supervisor for each of the centers in the state. This is a half-time position for a local school district employee, who works with the UNI faculty member assigned to the region, to supervise student teachers.

With such a diverse and dispersed group participating in student teaching, communication and coordination are major problems. To deal with these problems, a UNI group created a teleconferencing system that allows students, faculty, and cooperating teachers who have access to a personal computer and modem to exchange electronic mail and participate in a wide range of electronic conferences. The system has been in place for almost 10 years and staff and students have both felt the benefits. Conferencing on “caucus” may take the form of public discussion of items which anyone on the conference may read, or private messages. Participants with diverse perspectives are able to contribute freely and at their own convenience to continuous discussions related to teacher education. Students, faculty, practitioners, and administrators—though separated by hundreds of miles—have an avenue for mutual problem solving and the exchange of ideas.

Prior to the electronic conferencing system, the 10 faculty coordinators met face-to-face on campus once a month to discuss matters relating to teacher preparation. Now they are in almost daily contact through the network. This has had multiple effects. First, it has increased the sense of connectedness for the faculty coordinators—both among themselves and with campus colleagues. Second, it has improved the productivity of the monthly face-to-face meetings. With the regular contact in between meetings, more work can be accomplished so that face-to-face meetings concentrate on matters that can best be handled in that medium. Further, the work of the group is enriched by the addition of the clinical supervisors and the cadre members. The network helps forge relationships between the academic and the practitioner, a connection vitally important for a college of education.

The dean and a faculty member describe benefits of the electronic mail/conferencing system for student teachers:

> The student teaching experience is an intense and crucial, formative experience. It is a time when all the preparatory training and experience is brought to bear in an actual classroom experience of significant duration. In a conventional student teaching situation, the student teachers have access to the cooperating teacher in whose classroom this experience is taking place, the supervising faculty member from the university, and their peers in weekly face-to-face seminars.
>
> The addition of the computer conferencing networks to this experience accomplishes several important things. First, it expands the resource base for the student teacher. In addition to the available resources mentioned above, the student can now have access to faculty coordinators, clinical supervisors, and peers across the state. Furthermore, the students may now have access to resource people back on campus including professors in the content areas or methods areas, or library and media staff. We have had student discussions taking place on the system with library resource people who were following the online discussions. On occasion, the resource people would enter the discussion, noting that there was material available in the UNI library for a problem the student seemed to be having. The student would acknowledge that the material would be helpful and the material was mailed immediately on loan. Similar offers of counsel from supervisors and peers represent significant enhancement of resources during this critical period.
>
> Second, the student has an alternative and supplementary communication medium. Given peoples’ schedules and relative comfort levels with face-to-face communication, this network

represents another way to connect with those who can be of help during the student teaching experience.[91]

Outreach is a large part of UNI's daily operations, and the teleconferencing system is also used for outreach activities in which school administrators around the state present problems or pose questions for input from UNI faculty and other administrators.

Lessons Learned

A number of lessons have been learned from the process at UNI:

- **Institutional support and recognition from the university leadership are important.** At UNI the central administration demonstrates in many ways that teacher education is an honorable and valued part of the university's academic mission. The often unspoken but understood opinion of an institution's leadership about teacher education can facilitate—or hinder—reform efforts. Institutional support can be nurtured and encouraged, especially with leadership from a dean who supports technology.
- **Major changes do not always require grants or additional funds.** Neither the university nor the college of education are well endowed. Most of what UNI has accomplished has been done by reallocating existing funds. Over a period of seven years, UNI made many internal adjustments in personnel, budget allocations, and priorities to boost technology-related initiatives.
- **Grassroots leadership across the college is critical, too.** Which technologies are supported and how they are used was decided by college of education faculty, department heads, and program coordinators. The dean was a supporter, but the faculty took ownership of the technologies in use.
- **New faculty can be a significant factor in supporting technology.** Over the next decade the majority of faculty in many colleges of education will change through retirements or resignations. As search committees are formed, hiring faculty who use technology in the courses they teach can be an effective way of increasing the percentage of faculty who integrate technology into teaching.
- **Identify people with the talent and interest to succeed in technology reforms.** Do not spread resources thinly, across people or across areas of technology concentration; UNI, for example, has chosen to emphasize telecommunications, rather than cover all technologies.
- **K-12 teachers can be a significant source of leadership.** Much of what UNI teacher education students see and learn about technology in education comes from the innovative uses in the lab school. Also, since about 90 percent of the lab school faculty use technology in their classrooms, they are another source of influence on traditional teacher education faculty.
- **Do not push technology.** UNI's approach to technology diffusion targets problem areas—such as communicating with scattered student teachers—and suggests ways technology can improve the quality of instruction.

Vanderbilt University, Peabody College

Teacher education students at Peabody College use technology extensively as an integral part of their professional preparation. Peabody's approach to teacher education attempts to duplicate the richness and complexities of a K-12 school setting using a blend of video and computers, primarily through video case studies of teachers in real classrooms. This approach brings to preservice teachers a clinical experience previously not possible.

[91] Mike Waggoner and Thomas Switzer (1991), as quoted by Mergendoller et al., op. cit., footnote 61, p. 27.

A number of factors make Peabody's approach feasible. A relatively small number of enrolled students—about 20 percent—are preparing to become classroom teachers, so the student-to-teacher ratio is low. Also, an onsite research and development center, the Learning Technology Center, has for a decade investigated complex teaching and learning issues in K-12 education, so the college has been influenced by the center's findings over the years. In addition, teaching is highly valued by Vanderbilt's leadership, with the chancellor an outspoken advocate for the profession—as well as for technology.

Building Technology on a Constructivist Learning Base[92]

Cognitive science is a highly respected specialty at Vanderbilt. There are faculty groups pursuing this in both the College of Arts and Science and Peabody College. The long-standing interest in the science of human learning has shaped much of Peabody's technological contributions. It seems quite natural that themes of learning, teaching, and technology permeate Peabody College. The dean of Peabody summarized the college's perspective in this way:

> Our goal has been to find ways that advanced technologies can capitalize on what cognitive science has learned about knowledge and its acquisition, and the social process of learning, to design environments that assist teachers and students in the transaction of the learning process. This contrasts with the beliefs of some who have assumed wrongly that learning is a singular activity and that technologies will transform education by totally replacing teachers.[93]

For the last decade, Peabody College has been developing innovative uses of technology to enhance learning. With deep roots in cognitive science and an interest in constructivist learning principles, researchers at Peabody's Learning Technology Center developed a series of technological experiments to test a new approach to learning. In the early 1980s, they were studying that bane of 5th-grade math—the story problem. Sensing that the problem for most students lay not in their math skills but in the abstract quality of the story problem itself, they sought to "anchor" the problem in a rich story context. They caught the attention of many educators when they put on videodisc portions of the popular Hollywood movie *Raiders of the Lost Ark* and made the disc into an experimental anchor for problem-solving instruction. Viewers were asked to solve problems such as estimating the breadth of a pit-trap and the height of a tomb door using only the information that Indiana Jones, who stood next to the pit and the door, was 6 feet tall.

Later, sensing the limitations for school-based instruction of a made-for-entertainment video, they began developing a special purpose adventure video that would support mathematics instruction in the middle grades. Titled the *Adventures of Jasper Woodbury*, it contained (eventually) a number of real-world, compelling problems that required problem-solving skills and math to solve.

Other projects emerged built on the same anchored instruction philosophy. In time, various faculty recognized the potential of the anchored instruction approach for teaching college students how to teach math. These insights fit nicely with the growing recognition in the 1980s of the importance of case-based instruction to provide opportunities for novice teachers to confront the complexities of instructional decisionmaking. When, in the late 1980s, funding opportunities for new teacher education materials became available from several federal agencies (the National Science Foundation, the Fund for the Improvement of Post-Secondary Education, and the U.S. Department of Education), a cadre of Peabody educa-

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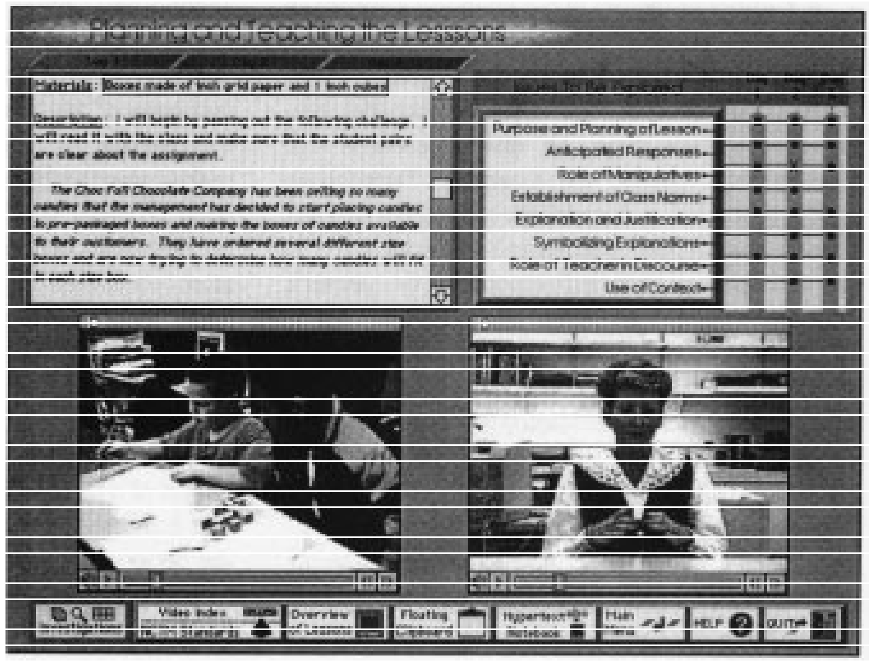
[92] Constructivist learning refers to a view of learning in which students construct their own knowledge based on exploration, evaluation, and revision of ideas, drawing on prior knowledge and understanding.

[93] James Pellegrino, as cited in Mergendoller et al., op. cit., footnote 61, p. 53.



JOHN E. HARWOOD, VANDERBILT UNIVERSITY

At Peabody College, Vanderbilt University, "video cases" are used by teacher education students to view teachers in action in the local schools. A videodisc controlled by Hypercard software allows the teacher education students to watch any number of video segments in any order. It is also possible for the students to stop the video at key points and enter their own comments in en electronic notebook, which is collected and reviewed by the college instructor.

tors applied for monies to extend the anchored instruction approach to the training of future teachers. Several of their products are centered on technology.

Peabody Integrated Media Approach

The Peabody Integrated Media Approach (PIMA) extends the anchored instruction model by using videotaped cases of real teaching, which are then **brought** to the college classroom for viewing and discussion as a way to build the clinical skills of potential teachers. Although it is no substitute for actual experience managing a classroom of children, PIMA is a valued contribution to the education students' understanding of teaching practice and also indirectly builds their computer skills. A basic assumption of Peabody's approach is that teachers cannot be told how to practice professionally; in other words, readings and lectures alone do not provide the full scope of what they will face in the classroom.

Whether in reading and language arts or math education class, teacher education students at Peabody do more than just watch a teacher in action; they use video footage of classroom teachers-which has been converted to videodisc and is controlled by computer—to analyze and discuss teaching styles or strategies and comment on the teacher's performance. In the math education class, for example, students use Hypercard to control the videodisc presentation, so they can jump forward to a different part of the video or review a segment already seen. Students can stop the video at key points, enter comments in an electronic notebook, and print out their comments. The notebooks are collected electronically at the end of the class for the instructor to read.

Virtual Professional Development

For more than eight years, Peabody faculty have been developing a variety of electronic supports for teacher education, including electronic lecture outlines with "buttons" accessing bibliographic references, video illustrations or other information the instructor might want to use during a class discussion, video-based cases for analysis, instructional resources for preservice teachers (sample lesson plans, activities materials, etc.), miscellaneous class assignments, and so on. These materials are organized in a virtual environment called the PPDS—Peabody Professional Development School (see figure 5-1).

PPDS is a hypermedia map of a school that links students to these different resources by calling for them in the appropriate place. For example, the resources are organized into "rooms" and are accessed through icons, such as furniture or objects in the rooms. Students "entering" the PPDS sign in at the virtual office by logging onto the system. The PPDS offers a variety of activities; for example, the Demonstration Classroom is a "place" where preservice teachers can watch assigned elementary school math and science lessons or check the filing cabinet for more resources, written lesson plans, or additional information about the math involved.

Each time students use the PPDS they not only access useful materials, but also become more familiar with the technology. More recently, education students have been creating and entering materials into the PPDS resource files; previously only Peabody faculty contributed materials. All the data have been organized, indexed, and entered into the school's integrated media database, and it is now available for future teacher education students. This type of activity provides opportunities for teacher-education students not only to become more facile with technology, but to develop a sense that technology can be an integral part of the teaching/learning process.

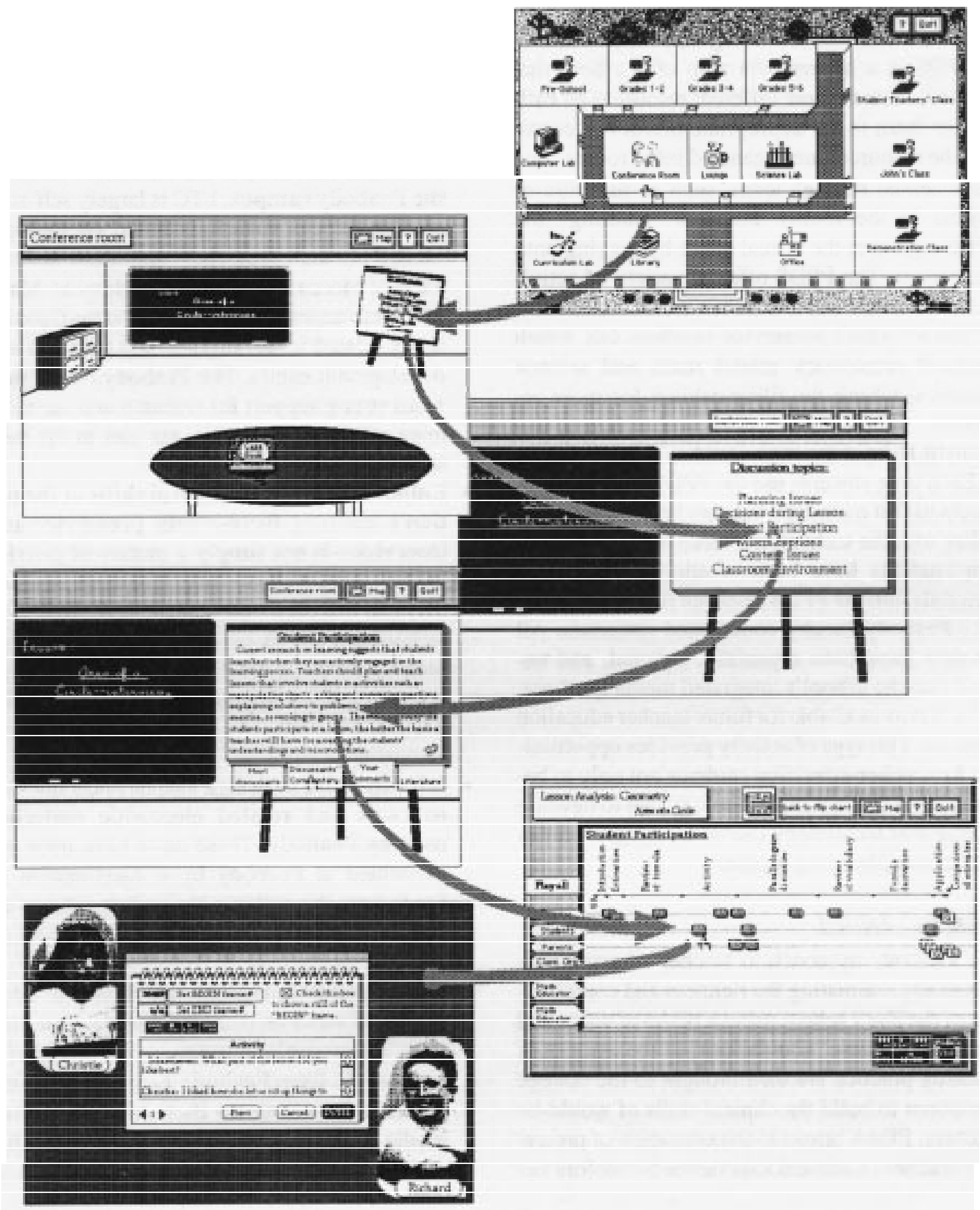
Lessons Learned

The Peabody approach to teacher education involves approximating the richness and complexities of the K-12 school using a blend of video and computers. These "simulations" of the realities of teaching practice are then brought to the college classroom to build the clinical skills of would-be teachers. PIMA brings to the education of preservice teachers a clinical experience heretofore not possible. While not a substitute for actual experience managing a classroom of children, PIMA makes a valuable contribution to students' understanding of teaching practice while indirectly building their computer skills. There are a number of factors that make Peabody unique:

- **The Learning Technology Center is clearly a catalyst that shapes fundamental ideas on the Peabody campus.** LTC is largely self-supporting through funds generated by multiple funded research projects,[94] and it has become a sort of Mecca for educators worldwide. Many of the advances at the education school are directly related to advances at this research and development center. The Peabody model provides strong support for research and development efforts in education, not just in the hard sciences.
- **Enhancing the technological skills of the nation's teaching force—both preservice and inservice—is not simply a matter of providing them with classes and workshops** where they can learn the well-accepted approaches to technology use in classrooms. The developments at Peabody are a result of the technology research and development efforts of the faculty itself, and the faculty's access to a rich array of resources.
- **It is expensive to design and develop the video cases and related electronic materials used by Peabody.** These costs have been underwritten at Peabody by a combination of funds from the college, Vanderbilt University, business and industry, and various federal sources.
- **It is not clear how easily teacher-education faculty at other institutions could adopt Peabody's electronic resources "off the shelf" and benefit from Peabody's considerable experience in setting up their own integrated media approach to teacher education.** But these resources (the video cases and related

[94] Several federal programs have contributed to the Learning Technology Center's research, including the National Science Foundation and the U.S. Department of Education's Fund for Improvement of Post-Secondary Education.

FIGURE 5-1: Peabody College's Virtual Professional Development School



To organize all the resources available to teacher education students, Peabody has created a virtual environment called the Peabody Professional Development School. PPDS is a Hypermedia map of a school; each room represents different resources. By clicking on the icon-for example, the conference room in this illustration-students have access to "conference' resources, such as a flip chart. By continuously clicking on the appropriate icons, students can browse and navigate their way through PPDS to access materials that will help them achieve instructional goals.

SOURCE: Peabody College at Vanderbilt University.

"contents" of the Peabody Professional Development "School") have characteristics that are different from both college textbooks and printed case studies used in business-school education programs.

- **The clinical approach to teaching entailed in PIMA requires a lot more time and involvement from college instructors than the traditional lecture/discussion formats that characterize much of college teaching.** To induce faculty at other institutions to adopt PIMA may require additional incentives.
- **Implementation of PIMA requires an expensive infrastructure**—both a technological infrastructure (computer laboratories) and the staff to keep it working.

CONCLUSIONS

These examples are promising, but they represent a limited scope of the potential for improving technology use within teacher education and, more importantly, improving teacher education overall with technology. As discussed earlier in the chapter, there is no central source for collecting data, sharing experience, or evaluating the effectiveness of teacher education in general, and certainly not for technology in teacher education in particular. Although advances such as telecommunications networks offer resources, without a road map there is no guarantee that the "information superhighway" will be used by teacher educators, K-12 educators, or their students, or that it will open up new worlds for them. But several conclusions can be drawn about the current status and possible future directions of teacher preparation.

Reform of teacher education should accompany any significant reform in K-12 education. However, this is a challenging task, given the general status of colleges of education in the university hierarchy, the exclusion of colleges of education from much funding at the state and federal levels, and the overall lack of priority given COEs in terms of funding or support for reform efforts. Enhanced resources for COEs that coincide with each national push for K-12 reform may increase the likelihood of real changes at both levels.

Furthermore, if technology is to break out of the isolated role it plays today and become an integral part of the teacher education curriculum, several things must happen. **An integrated curriculum infused with information technology requires that teacher education faculty and cooperating K-12 teachers model effective instructional technology use.** This interaction between K-12 schools and teacher education programs is an important, generally overlooked variable. It requires considerable training and support for current K-12 educators and for teacher education faculty in all segments of the teacher preparation program. Like K-12 educators, teacher education faculty need to see how information technology supports and facilitates instruction in their content or professional area.

Teacher education faculty need help integrating technology into the courses they teach. Since the majority of teacher education faculty completed graduate programs and taught in schools where technology was not a major part of the educational environment, it is not surprising that they tend to have limited experience with technologies for instruction. But simply telling teacher education students about what is possible is not enough; they must see technology used by their instructors, observe uses of technological tools in classrooms, and practice teaching with technologies themselves if they are to use these tools effectively in their own teaching once they graduate.

Colleges of education have much to learn from one another, and technology can be a catalyst to make the necessary connections. Teacher education programs need to provide considerable support, create and disseminate traditional and electronic resource materials, and revise incentives within teacher education to encourage teaching that integrates technology in instruction. A comprehensive strategy necessitates different instructional approaches in teacher education, such as video cases of teachers using technology in their classrooms, teaching lessons and activities for education students involving the use of technology, and supervising development and teaching of technology-supported lessons in cooperating schools. These approaches are not easily accomplished—all are expensive and require changes in the skills, perspectives, and attitudes of teacher education faculty and administration—but they are needed nonetheless.

College of education administrators are key players in any effort to improve preparation programs. Almost all of the universities considered exemplary in this area have deans and department chairs who see technology preparation as critical. Conferences, workshops, and publications for education leaders would make COE administrators and non-technology oriented faculty aware of needs and alternatives. Technology "gurus" in COEs should be encouraged to publish articles, make presentations, and offer workshops tailored to the needs of the nonspecialist, to extend their expertise to their less technology-oriented colleagues.

Limited technology resources are an issue for colleges of education. A reading instructor who decides to change textbooks for an introductory reading methods course does not necessarily set about to write his or her own textbook; he or she has a choice of at least a hundred texts already in print. If that same instructor decides to use Hypercard stacks or video cases of effective integration of technology in reading instruction, there are very few choices. The instructors may indeed be faced with the prospect of writing their own stack or creating their own video, and the COE needs to be prepared to support such innovation.

A few grant programs have targeted the creation of technology-supported materials for teacher education, but more support is needed. For example, the major video material for teacher education developed at Vanderbilt University and other institutions has been funded by federal, state, and corporate grants.

In addition, a national clearinghouse or distribution center for such materials is needed. A nonprofit clearinghouse that reviews submissions and accepts them for distribution, duplicates disks, or designs and produces supporting documentation and manuals would be a significant contribution to reducing the barriers to greater use of technology in teacher education. Many developers of such materials are not as concerned with making a profit, as they are on seeing their materials distributed to other teacher educators. Resources such as the Internet offer possibilities for broad dissemination of such materials.

Recognition of the importance of technology in teacher certification is gaining momentum. States take various and often mismatched approaches to certification and technology requirements. But guidelines do exist—such as those developed by the International Society for Technology in Education—and perhaps more need to be developed to help states figure out what teachers need to know about how to use technology effectively.

Colleges of education, states, and K-12 schools need to work together to develop a set of shared expectations for joint reform efforts, with a close eye to the role of technology in the reform. COE faculty rarely work with other agencies—such as school districts or state education agencies—on projects related to technology integration, in part, because K-12 reform and COE reform are typically considered separate issues. In fact, the two are directly related. New teachers leave COEs and enter classrooms where they inevitably face a multitude of challenges. Perhaps, as one educator suggests, the first step in terms of technology knowledge ought to be to "make the teachers fearless" in their attitude about technology.[95]

[95] Lee Ehman, Professor of Education, Indiana University, Bloomington, personal communication, June 27, 1994.

Technology and Teacher Development: The Federal Role

6

SUMMARY OF KEY FINDINGS

- The federal government has played a limited role in technology-related teacher development compared with states, universities, and school districts. In addition, the federal investment in technology-related teacher development has been less than that for educational technology hardware and software.
- Even so, past federal programs have piloted innovative educational applications of technology for teachers by providing significant support for professional development for particular groups of teachers, including mathematics, science, and special education teachers, and by providing funding for technology-related professional development in school districts that could not have supported it on their own.
- From the 1950s through the 1970s, the federal government funded several efforts to influence teacher training in technology-related areas; key programs included National Science Foundation teacher institutes, programs to improve teacher training and materials for children with disabilities, programs to familiarize teachers with instructional media and educational television, and initiatives to reform teacher preparation or spur innovation in K-12 education. These programs hold lessons for future federal policy.
- The federal role in technology-related teacher development has grown considerably since 1988 as a result of several new and expanded programs for math and science education and educational technology development. Federal actions in 1994 have created new opportunities for federal leadership in overall policies for education technology and in technology-related professional development. Key initiatives include the creation of an Office of Educational Technology in the U.S. Department

of Education, the state technology planning grants and other provisions of Goals 2000: Educate America Act, the expanded Dwight D. Eisenhower Professional Development program, the Title III programs for educational technology in the revised Elementary and Secondary Education Act, and programs to promote educational networking in the National Science Foundation and the Department of Commerce.

- The federal government has tended to focus more attention on inservice education rather than preservice education, channeling more support to K-12 schools than to colleges of education—an approach that seeks to address current needs but does not greatly influence teacher quality over the long term.
- The types of professional development activities supported with federal funds run the gamut from courses for teacher certification, to summer institutes, to one-shot workshops on specific topics. The role of technology in training also varies from short-term training on a specific type of software to semester-long projects that engage teachers in telecommunications networks. Federal projects include training *with technology* as well as training *about technology.*
- Much of the federal support for technology-related teacher development is optional in nature and small in amount, provided through competitive grant programs, or as part of programs with larger purposes. As a result, federal support for this purpose has been highly variable from year to year, piecemeal in nature, and lacking in clear strategy or consistent policy. Depending on how the federal government implements new initiatives for technology leadership, this situation could be improved.
- Federally funded programs are beginning to address several challenges implicit in providing technology-related teacher development. These include the need to train with higher intensity and longer duration, to translate exposure to cutting-edge technologies into viable classroom learning experiences, to provide extensive followup after the end of formal training, and to improve evaluation and dissemination of projects developed with federal funds.
- Projects helping schools develop access to the emerging National Information Infrastructure could provide resources and access to high-quality professional development activities for teachers. These grant programs have yet to focus on professional development as central issues, but offer great potential.

INTRODUCTION[1]

For several decades, the federal government has provided various forms of support to improve the preparation and professional development of elementary and secondary school teachers. Over the years, a small portion of this support has focused on helping teachers learn more about educational technologies, beginning with early projects to acquaint teachers with educational television and audiovisual technologies and continuing through current projects to train teachers to use computer models to teach physics.

[1] Much of this chapter is taken from Nancy Kober, "Teachers and Technology: The Federal Role," contractor report prepared for the Office of Technology Assessment, May 25, 1994. The contractor report was based on a review of the research literature and of the United States Code, compilations of federal education laws, the Code of Federal Regulations, the *Federal Register*, the *Catalogue of Federal Domestic Assistance*, federal budget documents, reports of the Congressional Research Service and the General Accounting Office, reports of the Federal Coordinating Council for Science, Engineering, and Technology, and a variety of federal agency publications. To determine which programs actually were supporting technology-related teacher training and to gather specific information on program activities, the contractor talked with federal program administrators, state and local project directors, and other experts, and reviewed federal evaluations, award abstracts, and federal and local project materials.

Federal support for technology-related teacher development[2] has grown considerably in recent years. But because it has come in small amounts from multiple programs with different purposes, this support has been somewhat haphazard and lacking in a clear strategy. **This situation may improve in the near future, however, as the Department of Education (ED) implements new educational technology programs under Public Law 103-382 (the Improving America's Schools Act), as states complete federally supported technology plans under Public Law 103-227 (the Goals 2000: Educate America Act), and as Congress and the executive branch confront critical decisions about educator access to the emerging national information infrastructure.**

As the federal government prepares for new leadership roles, it is important to examine current and past federal efforts to influence technology-related teacher development. This chapter:

1) describes and analyzes the current and emerging federal role in technology-related teacher development, including the major programs, activities, and strategies;
2) reviews historical federal efforts to improve teacher training in general and technology-related teacher development in particular;
3) examines the implications and lessons from current and past federal programs; and
4) discusses some key issues to be considered by Congress and the executive branch in formulating future federal policies in this area.

BACKGROUND ON THE FEDERAL ROLE

Primary authority for teacher preparation, licensing, and certification rests with the states, not the federal government. Substantial responsibilities also rest with colleges of education as regards preservice education and with local school districts as regards inservice education. **Given these constraints, the federal government has played a limited role in both the preparation and professional development of the average teacher.** Most federal efforts to influence teacher training over the past four decades have been confined to areas in which Congress has perceived an urgent need, such as strengthening American competitiveness through better mathematics and science instruction or improving education for children with disabilities and other special needs. Occasionally, the federal government has initiated broader reforms aimed at the general teaching force, with mixed results, as discussed later in this chapter.

Nevertheless, there are spheres in which the federal government has significantly influenced teacher training. Although federal training programs have never reached more than a small percentage of the total teaching force, over the years they have helped millions of teachers improve their knowledge, skills, and career advancement. It might even be said that the federal government helped give credence to the whole notion of inservice education and professional renewal through such early efforts as the teacher institutes sponsored by the National Science Foundation (NSF) in the 1950s, 1960s, and 1970s or authorized by the National Defense Education Act (NDEA) from 1958 to 1968 (see table 6-1).

In mathematics and science, enough teachers have participated in federally funded training to have had a significant effect on instructional quality or teacher supply. It has been estimated that past NSF institutes reached half the math and science teachers in the nation at some point; more recently, it has been estimated that one-third of all math and science teachers took part in some type of activity funded by the Eisenhower Professional Development program in 1988-89. The numbers

[2] As used in this discussion, *technology-related teacher development* means preparation and professional development for K-12 teachers and other education personnel that 1) aims to help them become familiar with any of several educational technologies and learn to integrate them into instruction, or 2) uses technology as a tool for providing training of any kind. Resources for technology-based training include telecourses, electronic networks, or computer- or video-based teacher training.

TABLE 6-1: Past Major Federal Programs in Support of Technology-Related Teacher Development

Program	Dates	Purpose	Costs[a] Total	Costs[a] Period	Numbers Trained[b] Total	Numbers Trained[b] Period
Training Teachers In Critical Subjects						
NSF Teacher Institutes	1954-75	Improve teacher skills in math and science.	$750 million	1958-74	350,000	1953-68
National Defense Education Act	1958-68	Improve teacher skills in critical subjects, including instructional media.	$148 million	1958-68	90,000 trained in NDEA institutes	1958-68
Training Teachers of Students with Special Needs						
Special Education Media Services	1964-86	Produce and disseminate materials for persons with disabilities, train teachers in their use.	$182 million	1966-80	15,000	1964-74
Part D Personnel Preparation (Special Education)	1966-present	Prepare teachers to teach children with disabilities.	$811 million	l966-90	5,000-7,000 annually in preservice; about 20,000 annually inservice	
Bilingual Education Personnel Training (Title VII, ESEA)	1974-present	Prepare bilingual education teachers.	$409 million	1975-91	36,000 per year	1977-78
Increasing the Supply of Educators and Recruiting New Teachers						
Higher Education Act Fellowships and Traineeships	1965-68	Increase number of teachers and improve their preparation.	$67 million	1966-68	4,140 fellowships and 3,850 traineeships	1966-68
Library Career Training	1965-present	Provide preparation and professional development for librarians, including school librarians.	$14 million	1966-91	4,309 fellowships	1966-91

Reforming and Improving Teacher Education						
Teacher Corps	1965-81	Prepare teachers to teach in low-income areas; provide more field experiences for teachers in training.	$460 million	1965-81	61,478 educators and 10,155 interns	1965-81
Education Professions Development Act	1967-76	Coordinate and expand federal teacher training programs, improve federal leadership.	$800 million	1967-76	300,000 trained	1967-76
Teacher Centers	1978-8" 1	Enhance teacher skills through teacher-directed professional development centers.	$47 million	1978-8"1	Not available	
Training Teachers To Stimulate Innovation and Reform						
National Diffusion Network	1974-present	Promote adoption of exemplary K-12 programs through teacher training and other means.	$145 million	1974-91	*60,000* educators in 7,000 schools	1974-77
Title Ill, ESEA Title IV-C	1965-81	Encourage innovation in education through teacher training and other means.	$1,443 million	1966-76	35,000	1968
Chapter 2, ECIA	1981-94	Support locally determined education reform efforts.	Not available		Not available	

[a]Costs are given for the years in which figures are available; costs are not available for years other than those listed.
b Numbers trained are given for the years in which data were collected; numbers are not available for years other than those listed.

SOURCE" Office of Technology Assessment, 1994. Based on Nancy Kober, "Teachers and Technology: The Federal Role," contractor report prepared for the Office of Technology Assessment, May 25, 1994.

of teachers receiving federally supported professional development in math and science could be considered potentially a critical mass for improvement within these disciplines.

Federal programs have also been a major force in the creation and growth of several teaching subspecialties, including special education, educational media, assistive technology for children with disabilities, and bilingual education.

Federal fellowships, scholarships, and other financial aid—beginning with the first fellowships under the Higher Education Act in 1965 and continuing through the Paul Douglas Teacher Scholarships, Perkins Loan Cancellations, and minority teacher recruitment programs of today—have changed the composition of the teaching force and attracted talented people to the profession who might have pursued other careers. Innovative federal programs such as the Teacher Corps helped develop new approaches to teacher preparation.

Similarly, over the past four decades the federal government has also undertaken efforts to develop, promote, and expand the use of educational technologies. However, these initiatives have received a very small slice of the federal education budget and have fluctuated greatly with changes in leadership and shifting goals and priorities in education. These programs have been research and development efforts, devoting more attention to promoting the development of and access to technology than they have to preparing teachers to use technology well.

Here, too, however, there are ways in which the federal government has influenced the training of teachers with and about technology. Some of the most innovative applications described elsewhere in this report—such as national telecommunications testbeds for students and teachers, video modeling of effective classroom interactions for teachers in training, or hands-on teacher research opportunities involving advanced technologies—have been developed, piloted, and disseminated with federal money. Federal dollars have helped develop and implement distance-learning telecourses for professional development and have exposed thousands of teachers to new uses and new ways of thinking about technology in the classroom.

CURRENT FEDERAL SUPPORT AND COMMITMENT

Sources of Federal Support

Many different federal programs currently support or could support technology-related teacher development. They range in size from large formula-grant programs that reach most school districts, such as ED's Eisenhower Professional Development Program, to small discretionary grant programs that serve a select number of teachers, such as the Summer Teacher Enhancement workshops administered by the Department of Energy (DOE) at research laboratories across the federal government. They range in mission from programs aimed at developing particular kinds of teachers, such as special education personnel development, to those aimed at enhancing the use of particular kinds of technologies, such as Star Schools distance learning. They range in directiveness from programs in which technology-related professional development is an integral requirement, such as the new state and local technology grant program under Title III of the Elementary and Secondary Education Act (ESEA), to those in which it is an entirely local option, such as Title VI of the ESEA program for educational innovation (formerly Chapter 2). And they range in target population from programs that focus on teachers only, such as the NSF Teacher Enhancement program, to those that involve both teachers and students, such as the Aerospace Education program administered by the National Aeronautics and Space Administration (NASA).

The federal government also promotes technology-related teacher development through means other than direct grant programs. For example, several federal laboratories and facilities donate personnel, time, space, and equipment to provide on-site training, research, and mentoring opportunities for K-12 teachers and students; many of these efforts involve advanced technologies. NASA and ED also have developed technology demonstration centers, or "classrooms of the future," where teachers can experience exemplary applications of educational technologies.

Federal agencies also sponsor electronic networks and databases aimed at teachers, students, and others interested in sharing or obtaining educational information, materials, and resources. The Office of Educational Research and Improvement (OERI) in ED has developed an Institutional Telecommunications Network serving all major OERI-supported research and development institutions. NASA has a Spacelink electronic information system to exchange information about aeronautics and space exploration. Other telecommunications networks are sponsored by NSF, the National Institutes of Health, and other agencies. In addition, federally sponsored clearinghouses often include technology-based materials among their resources or encourage potential clients to access their collections electronically.

The President, the Cabinet, Congress, and other federal officials also exercise leadership in educational technology by publicizing and rallying support for technology-related issues, by promulgating policy directives and executive orders, by establishing interagency committees or advisory groups, or by making high visibility technology appointments. Examples of federal leadership activities include the appointment of a Director for Educational Technology in the Office of the Deputy Secretary in the Department of Education, the announcement of an executive branch technology policy for the United States,[3] and the establishment of a Committee for Education and Training under the White House Office of Science and Technology Policy.

Level and Scope of Federal Commitment

It is difficult to know exactly how many federal programs are supporting technology-related teacher development in any given year and to what extent.[4] A starting point is to look at federal programs for professional development (teacher or administrator training) in general. A 1994 internal inventory of ED professional development programs identified 20 funded programs, with total funding of over $474 million in FY 1994, whose sole or major purpose was personnel development, plus another 44 that authorize significant resources for personal development.[5] Several more professional development programs are administered by other agencies.

In nearly all of the relevant programs, support for technology-related teacher training is an option rather than a requirement, and often a local decision. At the local level, there are probably thousands of federal grants and funded projects that might involve some form of technology-related teacher training, but getting precise information on these projects is a complex undertaking. With few exceptions, the federal government does not collect data from grantees in the format or detail needed to discern which projects are actually supporting technology-related training and how much they are spending for it.

Based on a review of federal program legislation and regulations, agency reports, project abstracts, discussions with federal and state officials, and other information, the Office of Technology Assessment estimates that at least 58 federal programs are currently supporting, have recently supported, or are likely to be supporting

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[3] See Executive Office of the President, *Technology for America's Economic Growth: A New Direction To Build Economic Strength* (Washington, DC: Executive Office of the President, 1993).

[4] There is also a semantic complication: namely, how one defines "program," especially in the case of agency-initiated activities below the budget line-item level.

[5] U.S. Department of Education, "Department of Education, Activities That Support Teacher and Administrator Training and Improvement," unpublished document, 1994.

technology-related teacher preparation or professional development to some degree.

Most of these programs are small by federal standards; a number have appropriations under $10 million. They differ by major purpose. Some focus primarily on *teacher development*. Many of these are programs to improve teacher skills in math and science, obvious subjects for infusion of technology because of the real-world links between science and technological applications. Others focus primarily on *developing and expanding the use of educational technologies*, with professional development authorized as a means toward this end.

Other relevant programs concentrate on *educating children with special needs*, such as Title I of the ESEA for disadvantaged children, the Individuals with Disabilities Education Act (IDEA), and the Bilingual Education Act. Technology is used frequently to deliver services in these programs, and *professional development for teachers of participating children* is an allowable use of funds. Also pertinent are certain programs that foster general school reform and allow *support for professional development as a vehicle for change.*

From this broad list of relevant programs, it is possible to identify 23 key programs that form the core of federal support for technology-related teacher training (see table 6-2*)*.

Most of the key programs are administered by the Department of Education. Several are overseen by NSF, consistent with the agency's science orientation and long-standing involvement in technology-related research and development.

Relevant programs are also administered by the Departments of Energy, Commerce, Health and Human Services, Agriculture, Defense, and Transportation, as well as NASA, the National Endowment for the Humanities, the National Endowment for the Arts, the Smithsonian Institution, and other agencies. These programs tend to be much smaller in scope and funding than the ED and NSF efforts. Many have a math and science orientation and offer institutes, workshops, or research opportunities for K-12 teachers at laboratories and other facilities. A smaller number improve teacher content and pedagogical knowledge for other disciplines.

Eligible grantees vary by program and include state educational agencies (SEAs), local educational agencies (LEAs), institutions of higher education (IHEs), and other public or private organizations. Several programs require or encourage collaboration among more than one entity, such as school districts and higher education institutions.

The remaining programs are smaller or less dependable sources of funding for technology-related teacher development (see table 6-3*)*. They include programs that authorize teacher training as one of many different allowable activities; that could support technology-related training under current guidelines but have not done so to any notable extent; that focus primarily on technology research and development, with small teacher training components; or that do not collect sufficient data to determine whether technology-related training is actually funded.

Estimating the level of federal expenditures for technology-related teacher development is not possible. In most of the 23 key programs listed in table 6-2, a small portion of total expenditures goes toward technology-related training. At the same time, unknown levels of support come from programs not listed in table 6-2, or table 6-3. **Because there are so few programs where specific data on technology-related training are available, OTA finds that there is no reliable estimate available for overall federal funding support for this purpose.**

Key Points

Whatever the current amount, several points can be made about federal funding for technology-related teacher development.

- **The amount of federal support for this kind of teacher training lags behind federal spending on educational technology hardware, software, equipment and facilities.** As one indicator, expenditures for computer hardware and software under a single program, Chapter 2 of the ESEA (now Title VI), have ranged from $50 million to about $100 million annually in recent years.[6] Star Schools projects have spent an average of 35 percent of total funding on equipment, or about $5 million to $8 million per year.[7] The amount for professional development in either of these programs is much less. Several million dollars more for infrastructure have come from the Public Telecommunications Facilities Program and other federal sources; again, teacher support for using these resources is extremely limited.

- **From all indications, federal support for technology-related teacher development has grown considerably since OTA first looked at educational technology in its 1988 report *Power On! New Tools for Teaching and Learning*.** Funding for the Eisenhower program, a vital source of support, more than doubled between FY 1988 and 1994, from $120 million to over $250 million. According to a government-wide inventory, 117 new federal programs for science, math, engineering, and technology education were created between 1988 and 1993, yielding a total of 290 such programs, of which 29 had teacher enhancement as their primary purpose.[8] Technology-related teacher projects have been designated as an absolute priority[9] in recent annual grant competitions under several programs—among them, the Fund for Innovation in Education (FIE), the Eisenhower National Program, the Star Schools program, and the technology and media program for individuals with disabilities.
- **Funding for technology-related teacher training is likely to grow**. The FY 1995 appropriations include $40 million for educational technology programs under the new Title III of the ESEA and an extra $70 million for the Eisenhower program. And, as explained below, technology-related training is given greater encouragement and more explicit attention in several ESEA programs, including Title I Eisenhower, Title VI (formerly Chapter 2), and bilingual education.
- **Support for technology-related teacher training is optional in most programs.** Although diverse funding sources for technology-related teacher development may appear to offer an abundance of opportunities, accessing federal funding for technology-related teacher development is not always easy. Many programs leave it up to state or local grantees to decide whether technology-related training—or for that matter, any kind of professional development—is supported and in what form. For example, although the Title I of the ESEA program for disadvantaged children, the IDEA state grant program for children with disabilities, and the Perkins Vocational Education Basic Grants program encourage funds to be used for professional development, local project directors must weigh the need for teacher training against other priorities, most notably direct student instruction. Often technology-related training and, in general, professional development are viewed as niceties rather than necessities. Even in competitive grant programs at the

[6] M.S. Knapp and C.H. Blakely, *The Education Block Grant at the Local Level: The Implementation of Chapter 2 of the Education Consolidation and Improvement Act* (Menlo Park, CA: SRI International, 1986); and Ruskus Joan et al., *How Chapter 2 Operates at the Federal, State, and Local Levels* (Washington, DC: U.S. Department of Education, 1994).

[7] About 130 separate staff development activities were offered in the 1992-93 school year. For the most part, general staff development consisted of a number of short "one shot" workshops presented as a teleconference, rather than a sequenced set of activities. Naida C. Tushnet et. al., *Star Schools Evaluation Report One* (Los Alamitos, CA: Southwest Regional Laboratory, July 1993), p. 49.

[8] Federal Coordinating Council for Science, Engineering, and Technology, Committee on Education and Human Resources, *The Federal Investment in Science, Mathematics, Engineering, and Technology Education, Where Now? What Next? Sourcebook* (Washington, DC: August 1993), pp. 10-17.

[9] An *absolute priority* means that only those projects that address a particular issue or activity (as announced in the *Federal Register*) will be funded in a given year. Priorities in national discretionary programs often change from year to year.

TABLE 6-2: Key Current Programs for Technology-Related Teacher Development

Program	Funding[a]	Purpose	Treatment of Technology-Related Training
Department of Education			
Title III, ESEA, Technology for Education	$40 million	Provide federal leadership and financial support to expand access to and use of educational technologies.	Secretary develops long-range technology plan; state and local grants must provide for ongoing professional development to integrate technologies in education.
Goals 2000: Educate America Act	$403 million	Encourage states to develop comprehensive school reform plans based on standards for student learning.	States must develop educational technology plans as part of overall improvement plans; act also established Office of Educational Technology in U.S. Department of Education.
Eisenhower State Grant	$321 million	Improve teacher knowledge and skills in math, science, and other core academic subjects.	Funds may be used for professional development in effective use of technology as instructional tool.
Eisenhower National Program	$39 million	Develop models of national significance in professional development in core subjects.	Funds may be used for training teachers in innovative uses of technology.
Star Schools	$30 million	Support acquisition and use of distance-learning technologies for education.	Funds may be used to develop and provide preservice and inservice distance learning for teachers and to train teachers to integrate telecourses for students into instruction.
IDEA Part D, Special Education Personnel Development	$91 million	Provide preparation and professional development to help teachers educate children with disabilities.	Technology-related training programs authorized; emphasis on assistive technologies.
IDEA Part G, Technology, Educational Media, and Materials	$11 million	Support research and development and technical assistance to advance technologies for persons with disabilities.	FY 1994 priority on organizational support and professional development.
Title I (Chapter 1) ESEA	$7,232 million	Provide educational services to help low-achieving children in low-income areas meet high standards.	Schools must devote sufficient resources to professional development; may include instruction in use of technology.
Bilingual Education Training Grants	$25 million	Support teacher preparation and professional development for bilingual education teachers.	Some projects involve technology; no specific encouragement for technology-related training in law.
Library Personnel Development	$5 million	Train and retrain school librarians and other library personnel.	Training in new technologies encouraged.
Christa McAuliffe Fellowships	$2 million	Provide fellowships for outstanding teachers to continue education, develop innovative programs, train colleagues.	Several fellows develop technology-related projects.

Title Vi/Chapter 2, ESEA	$347 million	Provide grants for range of state and locally determined school improvement activities.	Funds may be used for technology-related professional development at state/local option.
National Diffusion Network	$15 million	Disseminate and encourage adoption of exemplary education programs through staff training and other means.	Some current projects available for adoption have technology focus; professional development is primary strategy for helping schools adopt programs.
National Science Foundation			
Teacher Enhancement	$101 million	Fund teacher training programs in math, science, technology.	Many programs involve technology.
Teacher Preparation	$18 million	Support projects to improve undergraduate teacher preparation.	Projects must address preparation in new technologies.
Applications of Advanced Technologies	$10 million	Fund research and demonstration in revolutionary technologies for education.	Some projects have components for teacher support and development.
National Education Infrastructure for Networking	$15 million	Demonstrate innovative applications of networking for education.	Teacher support and development integral part of all projects.
OTHER FEDERAL AGENCIES			
Department of Commerce (NTIA)			
Public Telecommunications Facilities Program	$29 million	Supports innovation and capacity building of the nation's telecommunications infrastructure.	Supports distance-learning activities for teachers and students.
Telecommunications and Information Infrastructure Assistance Program	$64 million	Accelerate the use of telecommunications and information technology.	Supports telecommunications networks that can provide professional development for teachers as well as new teaching opportunities in K-12 classrooms.
National Endowment for Children's Educational Television	$2.5 million	Supports creation and production of television directed toward development of children's intellectual skills.	Much of the programming can be used in the classroom.
Department of Energy			
Summer Teacher Enhancement	$2 million (FY 1994)	Provide teacher training and research opportunities in federal laboratories.	Many projects involve training teachers in high technology applications in science
Teacher Research Associates	$1,9 million	Provide teacher summer laboratory experiences and training in science.	Some projects involve training in technology.
Environmental Protection Agency			
Environmental Education and Training	$2 million (FY 1994)	Train teachers and improve materials in K-12 environmental education.	Use of technologies encouraged.

[a] Funding levels are for the entire program, not just the technology-related teacher training projects or components All figures are FY 1995 unless noted otherwise.

SOURCE Office of Technology Assessment 1994 Based on Nancy Kober, "'Teachers and Technology' The Federal Role, " contractor report prepared for the Office of Technology Assessment, May 25, 1994.

TABLE 6-3: Additional Current Sources of Federal Support for Technology-Related Teacher Development

Department Of Education

- *Perkins Vocational and Applied Technology Education Act:* For basic state grants, states must include support for professional development for vocational teachers. "Tech-prep" projects linking secondary and postsecondary vocational education must include teacher training in tech-prep curricula. Teacher and administrator training and leadership development are among activities of National Center for Research in Vocational Education.
- *Part B IDEA State Grants:* States must have comprehensive systems of personnel development; may use federal grants for teacher training.
- *IDEA Special Purpose Programs:* Training for special education personnel is authorized under special purpose programs (i.e., Severely Disabled, Severe Emotional Disturbance, Deaf-Blindness, Early Childhood Education, and Transitional Services).
- *Regional Resources Centers, IDEA:* Services include teacher training, assistance to states regarding comprehensive systems of personnel development.
- *Indian Education Personnel Development and Special Projects:* Projects train Native Americans for careers as teachers; special projects support teacher professional development, including some technology-related training.
- *Territorial/ Teacher Training:* Preparation and professional development for teachers in U.S. territory schools.
- *Emergency Immigrant Education:* Inservice training is one of many activities to improve education of immigrant children in heavily impacted schools; some projects involve technology.
- *Javits Gifted and Talented Education:* Research, demonstration, and training projects to improve gifted and talented education; some involve technology.
- *National Writing Project:* Teacher training in writing instruction; encourages technology infusion.
- *National Science Scholars:* Scholarships to talented science, math, computer science, and engineering majors; recipients must teach in K-12 schools or pay back the award amount.
- *Fund for the Improvement of Postsecondary Education* (FIPSE): Projects to promote reform and innovation in postsecondary education; infusing technology and strengthening teacher education are among priorities.
- *Regional Education Laboratories and Educational Research Centers:* Research, dissemination, and teacher training on effective teaching and learning; improving instructional uses of technology is among priorities.
- *Language Resource Centers:* Teacher training is among the activities to develop better methods of teaching foreign languages; new technologies are an area of emphasis.

National Science Foundation

- *State Systemic Initiative:* State planning for systemic reform in math, science, and technology education.
- *Urban and Rural Systemic /initiatives:* Systemwide improvement plans in math and science education for cities with highest numbers of children in poverty and for rural areas; technology can be included.
- *Research in Teaching and Learning:* Basic and applied research on science and math education, including research on teacher uses of technology.
- *Mathematics and Science Teaching Perspective Component:* Teacher lab experiences with scientists and student Young Scholars.
- *Research Opportunity Grants:* Teacher research experiences with NSF principal investigators.
- *Advanced Technological Education:* Teacher preparation and professional development are allowable activities under the program to improve training of technicians for high-performance workplaces.

Department of Defense

- *Department of Defense Dependents' Schools:* Current activities target DODDs schools as a testbed for telecommunications networks.
- *Summer Associateships for High School Science and Mathematics Faculty* Research opportunities for outstanding teachers at U.S. Army labs.

National Aeronautics and Space Administration

- *NEWESTINEWMAST Programs:* Offer inservice training at NASA Centers to improve teacher knowledge in aerospace technologies.
- *Aerospace Education Services:* Teacher workshops on integrating aerospace topics into curriculum.
- *Education Satellite Videoconferences:* Teleconferences for inservice use on scientific topics.

Department of Agriculture

- **4-H** *Leadership Centers:* Land-grant colleges and universities train teachers and others to implement science-technology curricula.
- *Teacher Research Fellowship Program:* Teacher research opportunities with Agricultural Research Service scientists.

TABLE 6-3 (cont'd.): Additional Current Sources of Federal Support for Technology-Related Teacher Development

Department of Health and Human Services
- *Minority High School Student Research Apprenticeship Program:* Inservice and preservice training to minority teachers, teachers in largely minority schools, and minority undergrads interested in science teaching careers.
- *Summer Fellowship Program:* Inservice and preservice teacher training in microbiology lab techniques and electronic databases, summer internships in National Institutes of Health laboratories, workshops on incorporating new skills into curriculum.

National Endowment for the Humanities
- *Summer Seminars for Teachers:* Summer humanities studies for K-1 2 teachers; technology may be a resource.
- *Elementary and Secondary Education in the Humanities:* Program to improve humanities teaching in K-12 schools; includes teacher institutes in which technology may be a resource.
- *Special Opportunities in Foreign Languages:* Teacher institutes and other activities to improve foreign language instruction at all levels; technology may be a resource.

OTHER AGENCIES

Department of Transportation
- *Aviation Education Workshops:* Familiarizing teachers with aviation education curricular materials.

Department of Energy
- *Laboratory Partnerships, Local Programs, Regional Systemic Efforts:* Variety of lab-based teacher training and K-1 2 education improvement projects in science and technology.

Smithsonian Institution
- *Project SPICA* (Support Program for Instructional Competency in Astronomy): Summer institutes and teacher-leader training in astronomy for K-12 teachers and college faculty.

Environmental Protection Agency
- *Environment/ Education Grants:* Support can include teacher training to develop and implement models for environmental education.

National Endowment for the Arts
- *Arts in Education.'* Teacher professional development is one of many activities.

Interagency Initiative: NASA, NSF, and National Oceanic and Atmospheric Administration
- *GLOBE Program:* Grants for developing curricula, data collection and communication technologies, and teacher training in support of worldwide environmental science experiments.

This list is meant to be illustrative and is not a complete inventory of all federal programs with components for technology-related teacher training.

SOURCE: Office of Technology Assessment, 1995.

national level (e.g., the NSF Teacher Enhancement Program), the amount of support for technology-related teacher development varies from year to year, depending upon the priority given to technology or the kinds of proposals submitted. Until the passage of the Improving America's Schools Act, the two pieces had not come together: programs devoted to professional development did not mandate or recommend that grantees consider technology as either a topic for training or a mode for delivery, while programs that provide funds to acquire technology or expand its use did not always require attention to teacher training needs.

In part because of these characteristics, federal support for technology-related teacher development has tended to be highly variable, fragmented, and lacking in a unifying strategy or clear leadership. As a subcommittee of an ED steering group concluded in 1992, "Since the establishment of the Department in 1980, very little initiative or coordinated effort has been taken by ED to promote or guide educational technology efforts in the schools."[10] As discussed in detail later in this chapter, this situation has begun to change.

NEW OPPORTUNITIES FOR FEDERAL LEADERSHIP

The federal government is starting to exert stronger leadership in educational technology and teacher training, as signaled by several new legislative and executive initiatives. **As a result of new legislation, the Department of Education now has greater authority and stronger directives to develop and implement a coordinated federal policy for educational technology.**

▮ Goals 2000: Educate America Act

The major purpose of Goals 2000 is to encourage states to establish content and performance standards for student learning in core academic subjects and then to develop comprehensive school reform plans based on these standards. These state improvement plans must include "a process for providing appropriate and effective professional development, including the use of technology, distance learning, and gender-equitable methods, necessary for teachers, school administrators, and students to meet state content standards and state student performance standards." Furthermore, the act also authorizes grants to states to develop systemic plans, as part of their broader state improvement plans, to increase use of educational technologies for student learning and staff development. For FY 1994, $5 million was appropriated for this purpose.

The act also required ED to establish an Office of Educational Technology. This office is responsible for reviewing, coordinating, and overseeing federal educational technology policy.

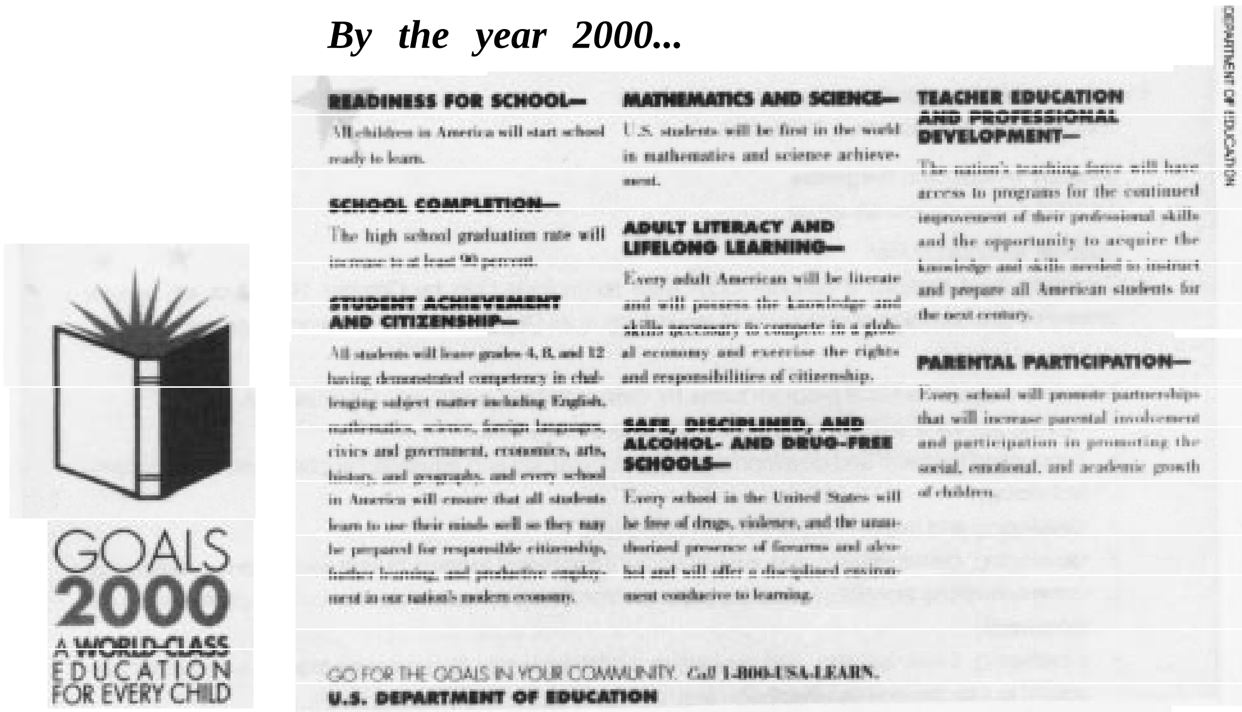
With encouragement from the Goals 2000 Act, national groups are developing voluntary national content standards in core subjects, including standards for what teachers should know and be able to do. The mention of technology in these standards could send a strong signal, while the omission of technology could constitute a setback. Together the provisions of Goals 2000 could give stronger federal encouragement to states and school districts to use technology both to support curricular reforms and to provide professional development.

▮ Improving America's Schools Act

The Improving America's Schools Act extends and amends most of the major federal elementary and secondary education programs supported under the Elementary and Secondary Education Act. It also contains far-reaching amendments affecting educational technology, most significantly the new Title III of the ESEA—the most comprehensive federal education technology legislation to date and a turning point in the federal role in educational technology. Title III authorizes several new federal leadership activities and grant programs in ED aimed at expanding access to and use of educational technologies, strengthening the technology infrastructure, and supporting technology-related technical assistance and professional development (see box 6-1). For FY 1995, the first year of funding, $40 million has been appropriated for the legislation. The Department has committed $27 million of this amount to a Technology Challenge grant competition. This program encourages schools, districts, research labs, nonprofit organizations and businesses to propose technology solutions to educational challenges and problems.

A key provision of Title III charges the Secretary of Education with developing a national long-range technology plan by October 1995 that includes strategies to:

[10] See Tom Hanley (ed.), "1992 Report of the Subcommittee on Educational Technology to the Steering Committee on Math and Science Education, U.S. Department of Education," n.p., November 1992, p. 98. This report noted that ED is quite limited in what it can do without congressional authorization or appropriation—a debatable point since in FY 1994 the Department designated technology-related priorities for several discretionary programs without changes in law.



Goals 2000 *legislation encourages states to increase the use of technologies for student learning and staff development, and requires that school districts provide professional development to meet state content and student performance standards.*

- encourage effective use of technology in all ED programs,
- facilitate technology use through joint efforts with other federal agencies,
- work with state and local agencies and the private sector,
- promote increased opportunities for teacher professional development in the use of new technologies, and
- accomplish other long-range goals.

This plan could provide focus and strategic planning for the federal role in educational technology, not only in ED but across government.

Also noteworthy is the new state and local technology grant program authorized in the new Title III, which has stronger recognition and mandates for technology-related professional development than any current federal program School districts receiving funds under this program are required, to the extent possible, to use funds to provide "ongoing professional development in the integration of quality educational technologies into school curriculum and long-term planning for implementing educational technologies."[11] Funds are also required to be used to expand technology applications to support school reform and ensure that schools have meaningful access to hardware, software, and connectivity, among other activities. School districts also must describe in their grant applications how they "will ensure ongoing, sustained professional development for teachers, administrators, and school library media personnel"[12] to further use of technology.

11 Section 3134 (4) of the Improving America's Schools Act.

12 Section 3135 (1) (D) (i), ibid.

BOX 6-1: Title III, ESEA—Technology for Education Act: Major Provisions Affecting Teachers

Part A—Technology for Education of All Students

Total FY 1995 Appropriation: $40 million

Subpart I—National Programs

FY 1995 appropriation: $3 million

National Technology Plan

Secretary must develop a national long-range technology plan by October 1995 that will include strategies to encourage effective use of technology in all Department of Education programs.

Federal Leadership

Secretary may use national program funds for various federal leadership activities such as:

- helping technical assistance providers improve their services;
- conducting research and development on interoperability and advanced applications of educational technology;
- developing and evaluating software and products;
- developing, demonstrating, and evaluating the educational aspects of high performance computing, communications technology, and the national information infrastructure in providing professional development;
- developing, demonstrating, and evaluating model strategies for preparing teachers and other personnel to use technology effectively; and
- encouraging collaboration with other federal agencies.

Subpart 2—State and Local Programs for School Technology Resources

FY 1995 appropriation: $27 million

Grantees

In years in which less than $75 million is appropriated (i.e., FY 1995), Secretary makes "challenge grants" to local consortia that include at least one district with a high concentration of low-income children. (If more than $75 million is appropriated, funds go to state education agencies based on Title 1, ESEA formula and states make subgrants to school districts).

Statewide Technology Plans

States must develop statewide technology plans (or use their Goals 2000 technology plan or a similar one) that must address long-term strategies for financing educational technology and serving districts with low-income children and high-technology needs.

Local Use of Funds

School districts shall use grant funds, to the extent possible, to:

- develop, adapt, or expand applications of technology to support school reform;
- fund projects of sufficient size and scope to improve student learning and, as appropriate, support professional development;
- acquire connectivity, hardware, and software to ensure that schools have meaningful access;
- provide ongoing professional development in integration of quality educational technologies;
- acquire connectivity with wide area networks; and
- provide educational services for adults and families.

Local Applications

School districts must describe how they "will ensure ongoing, sustained professional development for teachers, administrators, and school library media personnel served by the local educational agency to further use of technology."

BOX 6-1 (cont'd.): Title III, ESEA—Technology for Education Act: Major Provisions Affecting Teachers

Subpart 3-Regional Technical Support and Professional Development
FY 1995 appropriation: $10 million

Grantees
Educational laboratories and other regional entities, to develop regional programs in professional development, technical assistance and information dissemination.

Regional Professional Development
Regional professional development activities may include intensive school-year and summer workshops, video conferences, distance professional development, repositories of professional development resources, and more.

Subpart 4-Product Development
(No appropriation for FY 1995)

Purpose
Secretary makes competitive grants or loans to consortia to develop, produce and distribute technology enhanced instructional resources and programming for student instruction or professional development.

Part B—Star Schools
FY 1995 appropriation: $30 million
Star Schools program extended through FY 1995.

Part C--Ready-to-Learn Television
FY 1995 appropriation: $7 million
New program of grants to nonprofit entities to develop, produce, and distribute video programming promoting school readiness for preschool and elementary children and their parents.

Part D-Telecommunications Demonstration Project for Mathematics
FY 1995 appropriation: $2.25 million
New program of grants to telecommunications entities to conduct a national telecommunications demonstration project to help teachers prepare all students to meet content standards in mathematics. Grantees must use public telecommunications to train teachers in standards-based curriculum.

Part E—Elementary Mathematics and Science Equipment Program
New program, not yet funded, of formula grants to states and school districts to provide equipment and materials for hands-on math and science instruction in elementary schools. Funds shall not be used for computers and peripherals or for staff development.

Part F—Elementary and Secondary School Library Media Resources Program
New program, not yet funded, of grants to states and school districts to acquire school library and media resources.

SOURCE. Office of Technology Assessment, 1995.

A Title III program of grants to regional educational laboratories for technical assistance authorizes regional professional development activities in technology use. As discussed below, the Improving America's Schools Act also amends several other federal education programs to strengthen technology use.

1 Telecommunications Legislation Potentially Impacting Education

Congress has also been debating federal policy that would affect educational access to emerging information infrastructure. A number of bills were submitted in the 103d Congress, with varying approaches to regulation of access; it is expected that similar bills will be submitted in the 104th Congress. The final outcome of these debates will have a significant impact on the affordability, availability, and access to information resources for educational users. These bills could set in place a new system of educational services and materials for teacher and student use. Clearly teachers will need training and support if they are to derive maximum benefit from the new resources available.

However, as suggested by the past experience of many of the programs described below, ambitious initiatives do not always translate into better programs or stronger leadership. Budget ceilings can limit funding of new programs and appropriations increases for existing ones. New programs can be implemented effectively or poorly. Furthermore, a special office within an agency does not automatically guarantee better administration or coordination. Federal administrators must have the authority, tools, funding, and congressional and White House support to carry out the ideas embraced on paper in a technology plan.

MAJOR TECHNOLOGY-RELATED TRAINING PROGRAMS

As discussed above, there are two important ways that technology-related teacher training can be viewed: technology *as a subject for teachers to learn about or use* (i.e., as a resource for a range of K-12 instructional goals) and technology *as a mode for delivering teacher training of any kind*. This analysis looks at both these emphases in several key programs supported by the major players in this area: the Department of Education, the National Science Foundation, and, most recently, the Department of Commerce.

Department of Education Programs

Eisenhower Professional Development Program—FY 1995 Funding: $359 Million

The Dwight D. Eisenhower Professional Development program, originally authorized by Title II of the ESEA in 1988 and reauthorized under the Improving America's Schools Act, is now the largest federal program aimed at improving professional development. The program has two components: 1) the state grant program allocates funds by formula to states for grants to school districts (LEAs) and institutions of higher education (IHEs) for training K-12 teachers, and 2) the national program provides competitive grants from the federal level for innovative projects of national significance.

Until this year the program has focused on improving mathematics and science instruction through inservice and preservice teacher training. New amendments in the Improving America's Schools Act will extend Eisenhower professional development activities to other core academic subjects beginning in FY 1995, as long as math and science activities are funded at a level of at least $250 million per year.

Eisenhower state grant funding reaches 83 percent of the school districts in the nation—more than any other federal teacher training program.[13] It also reaches more teachers. In 1988-89, an estimated one-third of all math and science teachers in the nation took part in some type of activity funded by the Title II program.[14]

The forerunner of the Eisenhower program was the 1984 Education for Economic Security Act. This act allowed teacher training in "computer learning and foreign languages" only if math and science training needs had already been met. This wording presumed that learning about computers

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[13] U.S. Congress, General Accounting Office, *The Eisenhower Math and Science State Grant Program*, GAO/HRD-93-25 (Washington, DC: U.S. General Accounting Office, 1992), p. 26.

[14] Michael S. Knapp et. al., *The Eisenhower Mathematics and Science Education Program: An Enabling Resource for Reform, Summary Report* (Menlo Park, CA: SRI International,1991), p. iii.

(the dominant technology of the time) was considered a separate topic, not a means for teaching math or science. Revisions in 1988 expanded the policy to permit training in and instructional use of technologies (not just computers) as part of a math and science program and to allow purchase of hardware and software *if all other teacher training needs had been met*.

The 1994 amendments to the ESEA give much stronger encouragement to technology-related professional development. In their Eisenhower plans, states now must describe how they "will use technology, including the emerging national information infrastructure, to enhance the professional development of teachers." State and local Eisenhower grants may be used to provide professional development "in the effective use of educational technology as an instructional tool." Under the national program, the Secretary may fund efforts "to train teachers in the innovative uses and applications of technology to enhance student learning."

Both the state program and the national program are key sources of federal funding for technology-related teacher training. The most recent national evaluation of the state program, conducted in school year 1988-89, found that 20 percent of all LEA Eisenhower projects and 14 percent of all IHE projects provided support for computer education not connected to math or science; well over half of these computer education projects (62 percent) focused on staff development. In addition, a notable share of math- and science-oriented projects involved use of educational technology—in math, about 38 percent of the LEA projects and 41 percent of the IHE projects.[15] Support for technology-related training has continued in more recent years. A 1992 compendium of model programs funded through the state program included several technology-related training projects, such as helping teachers use laser holography to teach about light or use computers to model decisionmaking about natural resources.[16]

Under the national program, the FY 1994 grant competition designated three absolute priorities, one of which encourages model professional development projects that help teachers effectively use technologies in teaching math and science; electronic networking among teachers is required in all projects.[17] The 10 Eisenhower regional consortia funded by the national program to disseminate exemplary materials and provide technical assistance have also provided technology-related training to teachers.[18] Other national program grants are supporting projects to establish an online network to enable teachers to communicate with the National Clearinghouse for Mathematics and Science Education, implement statewide telecommunications networks for teachers, develop video teacher training modules, help teachers use networks to enhance instruction, and train teachers to integrate computer technologies into math instruction for Indian children.[19]

What impact has the Eisenhower program had? A recent evaluation found that the quality of LEA-supported training varied, from well-designed staff development that clearly influenced teacher thinking and classroom practices to "ad hoc training that appeared to contribute little to improved practices."[20] The study also uncovered mixed results regarding the impact of Eisenhower program participation on teacher classroom practices and

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[15] Ibid., pp. 15-18.

[16] Triangle Coalition for Science and Technology Education, *State Model Programs* (College Park, MD: Triangle Coalition, 1992).

[17] *Federal Register*, vol. 59, No. 84, May 3, 1994, p. 22910.

[18] Keith M. Kershner, "Eisenhower Regional Consortia Progress Update," *Dwight D. Eisenhower Mathematics & Science Education*, vol. 3, No. 3, fall 1993, pp. 6-7.

[19] U.S. Department of Education, *Dwight D. Eisenhower National Program for Mathematics and Science Education: Project Abstracts* (Washington, DC: 1994).

[20] Michael S. Knapp et. al., op. cit., footnote 14, pp. iv-v.

Star Schools funding has brought experts into even the most remote classrooms. Here Gene Cernan, the last astronaut to walk on the moon, discusses space exploration with students and teachers over an interactive instructional television network.

student learning.[21] And much of the Eisenhower-supported training was of low-intensity-an average of six hours of training per participant per year in LEA projects in 1988-89.[2]

In response to these findings, the Department of Education revised program regulations in 1992 to encourage projects of longer duration.[23] In the 1994 amendments, Congress directed all Eisenhower projects to support ''sustained and intensive high-quality professional development" that will have a lasting impact on teacher performance, become part of the everyday life of the school, and be oriented toward continuous improvement.

Star Schools, Title III-B of the ESEA-FY 1995 Funding: $30 Million

With an appropriation of $30 million for FY 1995, ED's Star Schools program makes grants to telecommunications partnerships to support the use of distance-learning technologies to improve student instruction in math, science, foreign languages, and other subjects. A large share of Star Schools funding is used to acquire and operate distance-learning equipment and to develop and deliver programming mostly aimed at students.[24]

Teacher professional development has always been an allowable activity under the program; the 1991 amendments required partnerships to offer a range of courses for educators with different skills and to train participating teachers to use telecommunications equipment and integrate distance-learning activities into the curriculum. In FY 1991, an estimated 22,600 teachers participated in Star Schools staff development activities and another 720 teachers received college credit courses through the system.[25] In 1992-93, about 130 different general staff development activities were offered by Star Schools partnerships, varying in length from l-hour to 6-hour segments, with some 10-hour telecourses. Most of these activities were "one-shot" teleconferences, and most were underused. A recent national evaluation suggests that **"general staff development was perhaps the weakest component of Star Schools** projects." [26] Many of the distance-learning staff development activities imparted information to teachers as passive recipients-in other words, old delivery in a new package. Effectiveness

[21] Ibid, p. 23.

[22] Ibid, p. iv.

[23] James B. Stedman, "Eisenhower Mathematics and Science Education Act: Overview and Issues for Reauthorization," Congressional Research Service, Library of Congress, CRS Report for Congress 93-5 EPW, December 1992, p. 12.

[24] Tushnet et. al., op. cit., footnote 7, p. 2.

[25] U.S. Department of Education, ***Annual Evaluation Report: Fiscal Year 1991*** (Washington, DC: 1992), p. 614-2.

[26] Tushnet et al., op. cit., footnote 7, p.71.

would probably increase, the report concluded, if projects used the interactive aspects of the technology to foster learning communities.[27]

The 1994 amendments to the ESEA continued a move begun by ED to strengthen professional development activities through distance learning. Star Schools funds may be used to develop and acquire preservice and inservice programs "based on established research," to establish teleconferencing facilities for making interactive training available to teachers, to provide professional development to teachers, to train instructors to use distance-learning equipment and integrate programs into the classroom, and to provide teacher training for teaching core subjects. Priority for funding is given to applicants that, among other characteristics, have substantial capabilities to provide professional development and to train educators to integrate telecommunications into school curriculum.

Title I of the ESEA— FY 1995 Funding: $7.2 Billion

Title I (formerly Chapter 1) is the largest single federal education program. Nearly every school district in the nation participates in the program, which provides supplementary instruction in academic subjects to low-achieving children in high-poverty schools. Because of its size and reach, Title I is a potent force in education today.

Professional development for teachers who work with Title I students has always been an allowable activity, although the amount or percentage of funding for this activity in recent years is not known.[28] It has been found, however, that staff development supported by Title I "is generally of short duration offering cursory coverage of multiple topics."[29]

Educational technologies, primarily computers, are used in over half of Title I projects.[30] Despite large investments in hardware and software and the popularity of computer-assisted instruction in Title I projects, in the past very little Title I support has been devoted to helping teachers of Title I students use technologies effectively. The extent of Title I staff development that addresses educational technologies is unknown,[31] although it was not among the 10 most common topics covered in staff development for Chapter 1 teachers in 1991.[32] Because Title I funding is so large, however, even a 1 percent share of Title I funds for professional development would amount to a $72 million contribution. Therefore, Title I presents a potentially large untapped source for technology-related professional development.

The 1994 amendments to Title I give greater emphasis to professional development and technology use. Title I schools must now "devote sufficient resources to effectively carry out" professional development activities, and schools that do not meet state performance standards must use 10 percent of their Title I grant for professional development. In addition, a new section on professional development requires every school district receiving Title I funds to provide high-quality professional development to improve teaching in aca-

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[27] Ibid., p. 78.

[28] Case study data from a U.S. General Accounting Office review of eight local programs found that in school year 1990-91, the school districts studied used from 0 to 4 percent of their Title I budgets for in-house training. The report also noted that it is possible that more funds were used for training but were categorized as nonsalary classroom services. U.S. General Accounting Office, *Compensatory Education: Most Chapter 1 Funds in Eight Districts Used for Classroom Services* (Washington, DC: 1992), pp. 12-13.

[29] National Assessment of the Chapter 1 Program, *Reinventing Chapter 1: The Current Chapter 1 Program and New Directions Executive Summary* (Washington, DC: U.S. Department of Education, Office of Policy and Planning, February 1993), p. 21.

[30] National Assessment of the Chapter 1 Program, ibid, p. 80.

[31] Mary Jean LeTendre, Office of Compensatory Education, U.S. Department of Education, personal communication, Nov. 17, 1993.

[32] Mary Ann Millsap, Marc Moss, and Beth Gamse, *The Chapter 1 Implementation Study, Final Report* (Washington, DC: U.S. Department of Education, 1993) p. 7-7.

demic subjects, and this may include "instruction in the use of technology."[33] The Secretary of Education may also fund projects to demonstrate promising Title I practices, including application of new technologies.

Title VI of the ESEA— FY 1995 Funding: $347 Million

Title VI (formerly Chapter 2),[34] which supports state and locally determined school reform efforts, has been a major benefactor of both school technology acquisition and general staff development. In school year 1991-92, about 72 percent of the districts in the nation used Chapter 2 funds to buy computer hardware and software, according to the most recent national evaluation.[35] The school districts examined in a substudy of that evaluation spent 17 percent of their Chapter 2 allocations on hardware and software. Extrapolated nationally, this would amount to $61 million from Chapter 2 funding for technology purchases.

During the same period, about 27 percent of school districts used some Chapter 2 funding on professional development (averaging about 13 percent of their local Chapter 2 allocations).[36] Again, if these percentages were extrapolated nationally, it would come to about $47 million for professional development.[37] It is likely that additional funding for professional development was reported under other Chapter 2 spending categories.

State education agencies (SEAs) may keep a percentage of their federal money for state initiatives (the percentage was reduced from 20 to 15 percent under the 1994 amendments). In 1991-92, states used about 12 percent of their Chapter 2 SEA allocations for professional development activities, or about $11 million. Funding for technology acquisition from this pot of money was less, about 2 percent of the SEA share, or less than $2 million.[38]

The national evaluation of Chapter 2 showed that technology-related training was a common topic for professional development at both the state and local levels. Of the SEA's that supported professional development with Chapter 2, 69 percent addressed the use of technology in instruction as a professional development topic.[39] For local education agencies supporting professional development with Chapter 2 funds, 39 percent addressed technology.[40]

In addition, the Chapter 2 legislation specifically authorized the use of funds for innovative technology education programs for students (which might also involve professional development for teachers). Although this initiative comprises only a small portion of SEA and LEA support,[41] it has encouraged interesting applications. For example, Maryland developed an interactive computer and video system that teachers could use to explore effective teaching methods keyed to specific learning outcomes in the state's

[33] Funding for this need not come from Title I; they may use Title I, Title II, Goals 2000, and any other sources to provide this professional development.

[34] Although technically now Title VI, this program is commonly referred to as *Chapter 2*, therefore this is the name used in this chapter.

[35] Joan Ruskus et al., *How Chapter 2 Operates at the Federal, State, and Local Levels* (Washington, DC: U.S. Department of Education, 1994), p. 73.

[36] Ibid., p. 175.

[37] Ibid., p. 18.

[38] Ibid., pp. 17-20.

[39] Ibid., p. 143.

[40] Ibid., p. 184.

[41] SEAs in the national evaluation and LEAs in the substudy each used 3 percent of their allocations for this purpose. ibid., pp. 17-18.

central reform initiative. In another example, a district in Texas supported the One Computer Classroom program, which includes software and related staff training to make efficient use of a single computer in a whole-class setting.[42]

When funding for technology-related professional development from all Chapter 2 components is totaled, it is still likely to be far less than the investment in equipment. **The new Title VI is likely to encourage a greater emphasis on technology-related professional development, by specifying that local grants may be used for professional development to assist teachers to use technological equipment and software effectively.**

Individuals with Disabilities Education Act—FY 1995 Funding: $3.3 Billion

The federal government has recently expanded support for technology-related teacher training under the various components of the Individuals with Disabilities Education Act (IDEA)—the major federal legislation for educating children with disabilities (authorization for IDEA is scheduled to expire in the 104th Congress). An impetus for this growth is the need for teachers who educate students with disabilities to be knowledgeable about adaptive and assistive technologies.

The largest IDEA program is the **Part B State Grant** program, which in FY 1995 will provide $2.3 billion to educate children with disabilities. Part B requires states to have a comprehensive system of personnel development that includes procedures for adopting promising technology, where appropriate, and permits funds to be used for teacher preparation and inservice training. Although 90 percent or more of Part B funds are used for direct services to students,[43] 29 states used some Part B funds in 1991 to support inservice training.

The major IDEA program for teacher training is the **Part D Personnel Development** program. Funded at $91 million for FY 1995, this program provides grants to IHEs, SEAs, and nonprofit organizations to train teachers, education personnel, and related services personnel to serve children with disabilities; to demonstrate new approaches to personnel training; and to help states carry out a comprehensive system of special education personnel development. Most of the funding supports undergraduate and graduate degree training in special education, through scholarships, fellowships, and institutional aid. Less frequently, grants are used for inservice training.

In 1990, provisions were added to Part D that specifically authorized training in instructional and assistive technology services, and this has dramatically increased the number of technology-related projects. At least 16 projects in 1993 involved a significant focus on technology. Most of these were graduate programs that trained specialists in assistive technology and augmentative and alternative communications. One project, for example, is developing the competencies of assistive technologists through computer technology. Another is developing teacher training modules using interactive television.[44]

Additional support for technology-related training is available through another IDEA program, the **Part G Program for Technology, Educational Media, and Materials.** Part G subsidizes research, development, and technical assistance to advance the quality and use of technology, educational media, and materials for individuals with disabilities. To date, the focus has been on research and development. For FY

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[42] Ibid., p. 57.

[43] U.S. Office of Special Education and Rehabilitative Services, *Implementation of the Individuals with Disabilities Education Act, Fourteenth Annual Report to Congress* (Washington, DC: U.S. Department of Education, 1992), p. 143.

[44] Max Mueller, Office of Special Education and Related Services, U.S. Department of Education, personal communication, Dec. 7, 1993.

1994, however, the Department of Education allocated $1.8 million from this program to fund innovative projects that combine organizational support and professional development in technology, media, and materials.[45]

Similarly, in the IDEA **Program for Children with Severe Disabilities**, one of five priorities for competitive grants in FY 1994 and 1995 was a model inservice training project to prepare personnel to educate students with severe disabilities in general classroom and community settings. Competency areas could include instructional technology and assistive technology.[46]

National Diffusion Network— FY 1995 Funding: $14.5 Million

Begun in 1974, the National Diffusion Network (NDN) is a national dissemination system to promote the sharing of K-12 education programs that have been validated as effective by a review panel. NDN projects span all subjects, specializations, and grade levels. Training teachers is one of the main strategies used by the program to help schools adopt exemplary projects developed in other sites. In school year 1990-91, more than 32,000 school districts adopted NDN projects, and nearly 91,000 educators were trained.[47]

The NDN was an early promoter of educational technology and early provider of technology-related teacher training. Several technology-related projects are included in the current roster of projects available for adoption. Examples are a program to enhance the ability of teachers to use videodiscs to teach core math concepts, a computer simulation program in environmental education, and a statewide program in Washington State that delivers training through satellite technology.[48]

The 1994 amendments outline several explicit NDN functions related to technology. NDN state-level staff must provide professional development to participating school districts; this training should help districts identify educational technology needs, secure technical assistance to meet these needs, and use technology to increase access to professional development.

National Science Foundation Programs

Teacher Enhancement— FY 1995 Requested Funding: $101 Million

Technology is embedded in the purpose of NSF's Teacher Enhancement program: "to improve, broaden, and deepen the disciplinary and pedagogical knowledge of teachers, administrators and others who play significant roles in providing quality science, mathematics, and technology education for students from pre-kindergarten through grade 12."[49] This program provides competitive grants to LEAs, IHEs, museums, and other organizations with records of excellence in professional development. In 1993, the program reached about 21,800 math and science teachers, each of whom was expected to train another four to five teachers.[50]

Many projects involve intensive summer workshops with regular followup during the school year, while others use research internships, workshops, seminars, and other inservice formats. Projects may target teachers in a single school district or in a state, region, or the nation.

[45] U.S. Department of Education, "Technology, Educational Media, and Materials for Individuals with Disabilities Program, Fiscal Year 1994: Application for New Grants," n.p., 1993.

[46] *Federal Register*, vol. 58, No. 119, June 23, 1993, p. 34189.

[47] Several districts adopted more than one NDN project. U.S. Department of Education, *Annual Evaluation Report, Fiscal Year 1991*, p. 611-2.

[48] National Diffusion Network, *Educational Programs That Work* (Longmont, CO: Sopris West, 1993), pp. 7-17.

[49] National Science Foundation, *Guide to Programs, Fiscal Year 1994* (Washington, DC: 1993), p. 16.

[50] Federal Coordinating Council for Science, Engineering, and Technology, Committee on Education and Human Resources, *Sourcebook* op.cit., footnote 8, p. 16.

Special emphasis is given to projects that lead to systemic reform in education or that provide leadership training to help effective teachers become change agents in their school or district.

Perhaps one-fifth of the current Teacher Enhancement projects focus specifically on technology, and a high proportion of the remaining projects use technology as a vehicle for teaching math and science. Recent projects have focused on helping teachers incorporate computer microworlds and simulations, new laboratory technologies, digital image processing, and telecommunications networks into their instruction. Others have trained teachers in rural areas through distance learning, encouraged teachers to develop video materials for classroom use, and promoted teacher collaboration through electronic networking.[51]

Teacher Preparation—FY 1995 Requested Funding: $18 Million

A new program within NSF, the Collaboratives for Excellence in Teacher Preparation, seeks to encourage comprehensive change in the undergraduate education of future K-12 teachers and increase the number of teachers well prepared in science and math. A reshaping of the former Teacher Preparation program, the Collaboratives strive to produce creative national models for teacher preparation that address both content and methods. Collaboratives must involve faculty from colleges of education; faculty from college departments of math, science, and engineering; and K-12 teachers and administrators. They may also include two-year colleges, community organizations, and public and private sector representatives.

The predecessor NSF program for Teacher Preparation supported several technology-related efforts, including projects to strengthen math teaching through hypermedia instructional materials, prepare K-8 teachers to use calculators and computers in teaching the fundamentals of probability, and integrate computer-based laboratory experiences into physical science courses for future middle school and high school teachers.[52]

The new program strengthens the emphasis on technology. Preparing prospective teachers to employ the latest technologies is one of the goals cited in program guidelines. Every Collaborative project must address the "preparation of students in the use of new tools and technologies." Funds may also subsidize workshops for faculty and mentor teachers to explore and design new methodologies and technologies.[53]

Other NSF programs are likely to be providing additional support for technology-related teacher preparation. For FY 1994, preparation of K-12 teachers was one of three special emphases that cut across all programs in the Division of Undergraduate Education, including programs for course and curriculum development, faculty development, improvement of mathematical science instruction, and laboratory improvement.[54]

Applications of Advanced Technologies—FY 1995 Funding: $10 Million

The Applications of Advanced Technologies program promotes research and demonstrations in "revolutionary" technologies that will be available in five to ten years, with the goal of speeding their transfer to the classroom. Although teachers are not the central focus, most projects have a

[51] Michael Haney, Teacher Enhancement Program, Directorate of Education and Human Resources, National Science Foundation, personal communication, Nov. 22, 1993; and National Science Foundation, *Directory of NSF-Supported Teacher Enhancement Projects* (Washington, DC: 1992).

[52] National Science Foundation, *EHR Directory of Awards, Fiscal Year 1990* (Washington, DC: 1992), pp. 148, 150, and 157.

[53] National Science Foundation, *Undergraduate Education, Program Announcement and Guidelines* (Washington, DC: 1993), pp. 21-22.

[54] National Science Foundation, *Guide to Programs*, op.cit., footnote 49, p. 18.

Following the standards set by the National Council for Teachers of Mathematics and those of the National Science Teachers Association, teacher training programs sponsored by the National Science Foundation encourage teaching with "hands-on" science, math, and technology activities.

component for teacher support and development.[55] These teacher activities are less formal than those sustained by NSF's Teacher Enhancement program, but are important because they yield valuable information about the kinds of support teachers need to assimilate advanced technologies into their instruction. Support has been in areas of intelligent tools and learning environments (e.g., an algebra workbench, microcomputer-based laboratories, exploration of virtual reality environments); knowledge-based systems and intelligent tutors (e.g., intelligent tutors in calculus, algebra, geometry, and science); and telecommunications and educational infrastructures (e.g., testbeds for educational networking in support of science and math education, worldwide Global Laboratory, and schoolwide Earth Lab projects).[56]

Networking infrastructure for Education–
***FY** 1995 Funding: $15* Million[57]

This program aims to demonstrate the most innovative applications of educational networking for students and teachers, with the goals of developing many different models for using networks effectively to improve education. Grants are made to consortia that include educational agencies or institutions, usually working with other public and private sector partners, and federal funds are matched with funds from other sources. Projects may address networking applications for everything from an entire state-such as a statewide educational network in New Jersey—to a single school with a teacher as principal investigator. Helping teachers learn to use networks construetively is an integral part of all the projects, as is providing ongoing professional development and support through networking.

■ Department of Commerce Programs

The National Telecommunications and Information Administration (NTIA) of the Department of Commerce funds a number of programs to support innovation and capacity building of the nation's telecommunications infrastructure. NTIA is scheduled to play a key role in fulfilling the Administration's goal of deploying an "information superhighway" as outlined by The *National Information Infrastructure: Agenda for Action.*[58] *The* distance-learning grant awards made by NTIA's Public Telecommunications Facilities Program (PTFP) since 1979 have created the underlying infrastructure for distance-learning facilities at the district and state level. The new Telecommunications and Information Infrastruc-

[55] Nora Sabelli, Applications of Advanced Technologies, Directorate for Education and Human Resources, National Science Foundation, personal communication, Dec. 8,1993.

[56] National Science Foundation, *Guide to Programs in the Division of Research, Evaluation and Dissemination* (Arlington, VA: September 1993), p. 15.

[57] $5 Million of this amount is set aside for projects in the Department of Defense Dependents' Schools

[58] U.S. Department of Co mmerce, ***The National Informatia n Infrastructure: Agenda for Action*** (Washington, DC: U.S. Gov ernment Printing Office, 1993).

ture Assistance Program (TIIAP) was created to accelerate the use of telecommunications and information technology in the public sector. Each of these programs require partnerships and matching funds, designed to magnify the impact of federal dollars. For example, the TIIAP FY 1994 grants were matched by state and private contributions at a 2:1 level, bringing the $24.5-million program to a $70-million total investment.[59]

Public Telecommunications Facilities Program—FY 1995 Funding: $29 Million

These grants are made to colleges and universities, school districts, public television and radio stations, and consortia of broadcasters and public agencies to develop Instructional Television Fixed Service (ITFS), microwave, satellite, or other telecommunications facilities to serve local communities. From 1979 through 1994, over 60 grants have been made to support telecommunications services benefiting K-12 school districts. Grants have ranged from $30,000 to $800,000.

Although not targeted to professional development or teacher training per se, the distance-learning projects supported under these grants offer a range of professional development opportunities for schools and districts. For example, with a NTIA grant of $72,546 the Los Angeles Office of Education constructed a satellite uplink facility for use by its Educational Telecommunications Network (ENT). ETN provides satellite-delivered programming for students and teachers in over 350 school districts in 12 counties serving 3 million students. For the 1994-95 school year, ETN's Teaching and Learning Channel is offering 180 hours of professional development for teachers, in topics including methods of teaching math and science, working with parents, and integrating ecology topics in the curriculum. Approximately 25,000 educators are reached in these programs.

Telecommunications and Information Infrastructure Assistance Program—FY 1995 Funding: $64 Million

This program supports both planning activities and demonstration projects for telecommunications networks serving nonprofit agencies and state and local governments. In the first year of this program, $24.4 million in grants was awarded to 92 projects. Eleven grants, totaling $3.72 million, were made to SEAs or school districts to provide telecommunication infrastructure development at the K-12 level. This represents 15 percent of the TIIAP FY 1994 grant support.[60] In addition, a number of other grants went to universities, state agencies, or other organizations for planning purposes or demonstration projects that will also benefit the K-12 sector. At one end of the funding spectrum is the $3,000 grant to the Hall Elementary School District No. 8 in rural southwest Montana to install an Internet connection in its two-room school building. The connection, the town's first, provided the 25 students and 95 residents of the town with access to Montana's statewide information services as well as national resources. At the other end of the spectrum, a $450,000 grant to Columbia University connects the university and the Environmental Defense Fund with students and teachers in the Harlem (NY) Economic Empowerment Zone. Environmental resources will be provided to teachers and students through the extension of high-speed networks and graphical interfaces for teaching. The project will include purchase and installation of new equipment in six schools, provision of curricular material and support, and necessary elements for connections to the university.

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[59] Emilio Gonzalez, Department of Commerce, National Telecommunications and Information Administration, Office of Telecommunications and Information Applications, personal communication, November 1994.

[60] Ibid.

National Endowment for Children's Educational Television—FY 1995 Funding: $2.5 Million

The National Endowment for Children's Educational Television (NECET) supports the creation and production of television programming specifically directed toward the development of fundamental intellectual skills of our nation's children. Although NECET primarily supports programming intended for general viewing, much of the programming it funds also has applicability within a classroom context. An example, of NECET-funded programming is "Wufniks!" This prospective series was supported by a FY 1993 grant of $157,903 for planning, development, research, scripting, and evaluation of a pilot. "Wufniks!" is intended to help 5- to 9-year-olds develop an awareness of, curiosity about, and engagement in general science, math, and technology. A followup grant of $100,000 in FY 1994 is supporting the research and development and scripting of six 30-minute episodes of the series.

SUMMARY OF FEDERAL EMPHASIS IN TECHNOLOGY-RELATED TRAINING SERVICES AND ACTIVITIES

The preceding program descriptions give a sense of the broad strategies and categories of federal support for technology-related teacher development. While there is great variety at the program or project level, some general conclusions about technology-related services and activities in federal programs can be drawn by looking at a number of factors, including the specific treatment of technology, program content and teachers served, the form of training, and uses of technology across programs.

■ Role of Technology in Training

Federally funded projects today use or address technology in much more diverse and innovative ways than they did just a few years ago (see box 6-2). By and large federal programs are moving away from treating technology as a compartmentalized subject or an end in itself (e.g., providing teachers with a computer "class") and toward viewing technology as a means of delivering, expanding, and changing instruction in a variety of subjects.

Often the focus continues to be educating teachers *about* technology. Activities in these types of projects vary in intensity and strategy from one-time training that acquaints teachers with a single application (e.g., how to use graphing calculators in math instruction) to ongoing support that helps teachers understand how using technology can change teaching style and instructional techniques (e.g., how to use global telecommunications to facilitate a hands-on, project approach to environmental education). In some programs, such as NASA's teacher activities in space science, real-world applications of technology also form the content being studied by teachers and students.

Some federally funded projects are exploring which technological applications are most appropriate for different types of learners, such as children with disabilities or those with limited-English proficiency. Others are exploring effective ways to integrate technologies into the teaching of particular subjects. As a result of the math and science orientation of so many federal training programs, the group that has been most served by federally subsidized training is math and science teachers at the middle and secondary school level. Recently, the math and science training needs of elementary teachers have received greater attention from these programs.

Far rarer is training that integrates technology into the teaching of history, social studies, the arts, or English. Prototypes do exist, however. For example, the National Writing Project supported by ED, which provides professional development in writing instruction, encourages the use of technologies in the writing classroom and has supported a teacher network. A project funded by the National Endowment for the Arts is training teachers to use video technologies as part of broader training in integrating media arts into the

BOX 6-2: Some Roles for Technology in Federally Funded Professional Development Projects

*Training **About** Technology*

- Acquainting teachers with the use of a specific technology, such as satellite technology, and assistive technology for children with disabilities.
- Familiarizing teachers with a variety of technology tools and applications, such as telecommunication networks.
- Training teachers to use technology to facilitate new instructional approaches (e.g., using networks to help students become investigators).
- Teaching teachers to integrate technology into a specific subject (e.g., using computer simulations in physics),
- Helping teachers learn to incorporate technology across the curriculum, such as accessing libraries, databases, and networks.

*Training **With** Technology*

- Delivering telecourses or teleconferences by satellite.
- Videotaping training sessions.
- Videotaping and critiquing of teacher performance.
- Modeling good instruction on video.
- Computer-assisted training modules for independent study.
- Using laboratory tools for research assignments or internships.
- Using telecommunications networks for research, interaction, and collegial work.
- Providing computer databases on instructional issues.
- Providing computer or video guides to accompany training materials.

SOURCE: Office of Technology Assessment, 1995

classroom.[61] A project supported through the Javits Gifted and Talented Education program used telecommunications to link civics teachers with mentors in the legal community.[62] A grant from the ED Fund for the Improvement of Schools and Teachers helped social studies and history teachers create multimedia lessons on a historical period, such as the 1920s, by accessing print, video, and studio materials with Macintosh computers and Hypercard software (see box 6-3).[63]

The expansion of the Eisenhower program to other academic subjects may expand these kinds of models of federal professional development programs for teachers of academic subjects other than math and science. Foreign language programs administered by ED, arts and humanities programs under the National Endowments, and others may have great untapped potential to reach a broader base of teachers and subject areas. To spur technology integration in other subjects, federal grant invitation guidelines could include language encouraging such projects.

Many federal technology-related training projects also address pedagogical issues, such as instructional methods and classroom management. Strategies for meeting the needs of special

[61] Vonnie Sanford, Ohio Art Council, personal communication, Dec. 16, 1993.

[62] U.S. Department of Education, unpublished 1992-93 abstracts from the Javits Gifted and Talented Students Education Program (Washington, DC: n.d., n.p.)

[63] Amanda Podane, University of California at Los Angeles, personal communication, Dec. 16, 1993.

BOX 6-3: How Some Federally Funded Projects Have Integrated Technology into Teacher Preparation and Professional Development

- Teachers learned to implement the "Jason Project" Curriculum, which uses interactive distance learning to 'lake students and teachers along" on undersea robot explorations; together they learn more about science, geography, social studies, and even Greek mythology in the process. ***Eisenhower Professional Development Program, Department of Education***
- Teachers created multimedia lessons for a thematic, interdisciplinary approach to history and social studies: a lesson on the 1920s, for example, might use photo images of the flapper fashions, readings from *The Great Gatsby,* and historical materials from newspapers. ***Fund for the Improvement and Reform of Schools and Teachers, Department of Education***
- Michigan school media specialists learned to use telecommunications technologies, to introduce networking in their schools, and help teachers in their schools develop lessons by accessing databases through the Internet. ***Library Education and Human Resource Development, Department of Education***
- A Star Schools partnership broadcast a six-session, nine-hour professional development telecourse to help middle school teachers use inquiry-based computer programs to support the kinds of math instruction called for in math teaching and learning standards. ***Star Schools, Department of Education***
- Undergraduate teacher education students learned how to produce multimedia materials for reading instruction. ***Fund for the Improvement of Postsecondary Education, Department of Education***
- Students, teachers, university faculty, and community members were linked electronically at a magnet school for math and science; teachers had continuous support through teleconferencing. ***Javits Gifted and Talented Education Program, Department of Education***
- Using McAuliffe fellowship money, an lowa teacher bought 18 electronic keyboards, and took them to area schools to show other teachers how to use them with computers for teaching music by recording accompaniments, transcribing arrangements, and coordinating playing among groups. Another teacher outfitted a school bus with computer-based multimedia technologies, and shuttling between two Kentucky schools, he showed other teachers and students how to integrate technology into all subjects. ***Christa McAuliffe Fellowships, Department of Education***

groups of children are a common theme, as is using a constructivist approach or a "discovery" approach to teaching. Sometimes pedagogical issues are the sole focus of training, as with certain teacher telecourses developed by the Star Schools partnerships. More often, pedagogy is addressed in tandem with subject-matter training. Some federal programs, such as the new Eisenhower program, require professional development to be based on solid research about effective teaching and learning.

Several federal programs expose teachers to state-of-the-art technology through research and training experiences in federal laboratories and facilities. This approach presents unique opportunities for teachers, maximizes the use of expensive federal resources, engages the expertise of federal scientists, and contributes in-kind support to training programs. Exposure to advanced technologies in a training situation creates a challenge for the teacher, however, who must figure out how to translate the new experiences and knowledge into something usable in the classroom, especially when the technology in question is neither practical for students nor accessible to many schools. Some projects have taken steps to address this problem. The Summer Teacher Enhancement Program requires teachers to develop lessons or experiments to take back to their schools and plans followup visits from scientists or research-

BOX 6-3 (cont'd.): How Some Federally Funded Projects Have Integrated Technology into Teacher Preparation and Professional Development

- At the National Wetlands Research Center in Louisiana, teachers spent four weeks in hands-on training and research projects involving light and electron microscopy, learned about the wetlands biosystem, and brainstormed ideas for incorporating microscopy into their curriculum. *Interagency Summer Teacher Enhancement Program, Department of Energy*
- Teachers learned to use the Geological Information Service natural resources database of the Columbia River Estuary to develop a project-oriented curriculum for secondary school students. *Environmental Education Grants, Environmental Protection Agency*
- Minnesota teachers focused on using constructive mathematical and computer models to study scientific phenomena. *Teacher Enhancement, National Science Foundation*
- Teachers and students in poor rural schools in Mississippi were able to access courses, Instructional support, and materials via nine multimedia Interactive Technology Centers housed at high schools across the state. *Public Telecommunications Facilities Program, Department of Commerce*
- By integrating multiple diverse computer networks across the State of Alaska, 81 percent of the population, including K-1 2 educators, will have non-toll access to a combined education/government/library network. *Telecommunications and Information Infrastructure Assistance Program, Department of Commerce*
- In the science and mathematics Teaching Teleapprenticeships program, teacher education students and practicing teachers participate in electronic network-based activities with K-12 students, teachers, university-based scientists, and teacher educators using specially developed communication tools for math and science education. *Applications of Advanced Technologies Program, National Science Foundation*

SOURCE: Office of Technology Assessment, 1995.

ers during the school year. To address this issue further, the Department of Energy is working with the Bank Street College of Education to synthesize research on effective transfer of advanced technologies into classroom settings.[64]

Federal programs are also encouraging professional development and preparation with technology—in other words, as a mode for delivering training. Federally funded projects are experimenting with the full range of options: distance learning, electronic networking, video training materials, videotaped models of effective teaching, videotaping and critiquing of novice teachers, computer-assisted training and modules for independent study, electronic libraries of instructional resources, and more. Networking, rare a few years ago, is receiving increasing attention in federal programs as a vehicle for teacher interaction with peers or students and for followup to formal training. Less common are applications that combine multiple technologies, although some of the national demonstration programs are working on this concept.

[64] Margaret Dwyer, Office of University and Science Education Programs, Program Evaluation Branch, U.S. Department of Energy, personal communication, Dec. 14, 1993.

BOX 6-4: Followup Strategies Used in Federally Supported Professional Development Programs

The value of professional development programs can be enhanced by providing followup and support after formal coursework ends. A number of approaches have been tried, including:

- newsletters, periodic mailings to participants;
- requirements for teacher participants to train or share information with others;
- requirements for teachers to develop projects or lesson plans to take back to school;
- scheduled reinforcement sessions, conferences, or meetings during the year;
- formal planning for curriculum implementation by teams of teachers;
- ongoing access to lending libraries, resource centers, materials, equipment;
- teleconferences, video conferences;
- on-site visits by trainers or colleagues; and
- electronic or video networking with fellow participants, trainers, experts, and others.

SOURCE' Off Ice of Technology Assessment, 1995.

Strategies for Followup and Support

What happens to teachers after formal training ends has been a critical issue in past and present federal programs. Recognizing this, programs such as the Eisenhower Professional Development Program, the NSF Teacher Enhancement program, and others are encouraging stronger followup. Some federal projects now require participants to make an upfront commitment to attend followup meetings during the year, develop projects and lesson plans to implement in their classroom, or share what they have learned with a certain number of other teachers (see box 6-4).

Particularly promising are approaches that use telecommunications networks or interactive video and audio to keep participants in constant connection with each other, their training leaders, scientists, or scholars. Access to networks can reduce the need for scheduled reinforcement sessions and can provide teachers with on-the-spot answers to questions. Some of the newest projects are building a requirement for followup networking into their training activities. The Department of Energy has supported the development of evaluation "templates" that local projects can use to determine whether they are including the most effective practices for training teachers; included in one template is the use of telecommunications for followup.[65]

Strategies for Magnifying Impact

To implement new technology-based knowledge and approaches in the classroom, teachers must have a number of supportive resources and conditions. These include:

- access to the technologies addressed in training;
- appropriate software, instructional materials, and equipment;
- availability of telephones in the classroom;
- complementary assessment practices;
- supportive scheduling and class assignment policies; and
- a school climate conducive to change.

Learning from some of the shortcomings of past teacher training efforts, many newer federally funded projects for professional development are attempting to address local organizational conditions in the design phase. Some programs are re-

[65] Ibid. The templates are included in National Center for Improving Science Education, *Profiling Teacher Development programs: An Approach to Formative Evaluation* (Andover, MA: The NETWORK, 1993).

BOX 6-5: Strategies Attempting To Magnify the Impact of Federal Support for Technology-Related Teacher Development

Past and current federal programs have not been funded at sufficient levels to undertake a massive upgrading of the general U.S. teaching force. However, a number of strategies have been used to expand and enhance the impact of federal professional development dollars. These include:

- training the "trainers of teachers," such as college of education faculty or district instructional supervisors;
- improving teacher preparation in colleges of education through new or better courses, stronger links with faculty in content departments, and other institutional reforms;
- targeting key teachers or "teacher-leaders" who train peers or promote change in their schools;
- requiring teams of education personnel from the same school or district to attend training together;
- supporting model or demonstration projects that can be disseminated and adopted by other districts;
- developing new organizational arrangements for training teachers, such as field-based training or collaborative training involving school districts, institutions of higher education, and other partners, and
- coordinating professional development with current curricular reforms, such as implementing new content standards for mathematics.

SOURCE: Office of Technology Assessment, 1995

quiring administrators to participate in training, encouraging administrator-teacher teams to participate together, requiring local funding contributions, or asking administrators to agree upfront to provide certain support after teachers return from training.

Federal programs have used various strategies to attempt to magnify the effect of limited federal dollars (see box 6-5).

HISTORICAL PRECEDENTS FOR TECHNOLOGY-RELATED PROFESSIONAL DEVELOPMENT[66]

The current efforts to support technology-related teacher development are not the first time the federal government has tried to influence teacher preparation and professional development in specific directions. In the 1950s,[67] the federal government began supporting efforts in which the strands of teacher training and educational technology intersected.

Much like the present role, past support for technology-related teacher development was mostly optional and came from diverse programs, including programs to develop and expand the use of educational technologies, to train teachers in math and science, to improve education of children with special needs, or to foster educational innovation. Also relevant are certain federal initiatives to reform general teacher preparation and professional development, such as the Education Professions Development Act (EPDA) (see table 6-l).

As with recent efforts, these past federal programs did not follow a neat linear progression but rather were marked by periods of attention and ne-

[66] For a fuller description of past federal efforts to influence teacher preparation and professional development, see N. Kober, "Teachers and Technology: The Federal Role," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, May 1994.

[67] Federal involvement in teacher preparation actually dates back to the Second Morrill Act of 1890 and the Smith-Hughes Act of 1917, both of which supported vocational teacher preparation. The history most relevant to this discussion, however, begins in 1954 with the first NSF institutes for secondary school teachers.

glect and propelled by frequently shifting congressional concerns—e.g., heading off Soviet technological threats, staffing federal programs for disadvantaged and handicapped children, or improving the educational quality. Over four decades, numerous programs were started, expanded, and revised—then later reduced, consolidated, eliminated, or allowed to expire, often for reasons that had little to do with continuing need or program quality. A review of some of the key historical efforts reveals parallels between past and present federal policies affecting teachers and technology.

Early Technology-Related Training Projects

In 1954, spurred by reports of increased Soviet production of scientists and engineers, NSF extended an existing program of institutes for college faculty to include an experimental summer conference for high school teachers. By the late 1950s, NSF was sponsoring a variety of *summer and academic-year institutes and training opportunities for high school teachers*.

Although the content of the NSF institutes was not specifically geared to technology—except for use of laboratory and other equipment—the institutes constituted a large-scale professional renewal effort that opened the door for more active federal involvement in teacher training and set a standard for quality. Early institutes were conducted on university campuses, taught by eminent scientists, emphasized disciplinary content knowledge, and targeted the most experienced or talented teachers and teachers of advanced high school subjects. Later institutes reached out to other kinds of colleges, involved content in more general science topics and teaching methods, and targeted elementary teachers, less well prepared teachers, new or re-entering teachers, and trainers of teachers.

Between 1958 and 1974, the "golden era" of NSF precollege institutes, the agency spent nearly $750 million for teacher training and upgrading.[68] **By 1974, about half of the nation's high school science teachers had participated in at least one NSF institute, according to agency estimates.[69]**

What was the impact of this investment? Studies found that the institutes generally succeeded in improving participants' subject matter competency and understanding of scientific methods and encouraged them to continue in their educational careers and assume leadership roles.[70] Research yielded conflicting findings as to whether benefits for teachers translated into improvements for their students; some studies said that pupils of participating high school math teachers had higher achievement scores than pupils of nonparticipants,[71] while others found no such relationship or insufficient evidence.[72]

Another seminal program was the National Defense Education Act of 1958, a collection of categorical programs to strengthen education in fields considered critical to national defense. Among the programs were several related to preservice or inservice training, including *loans and fellowships for undergraduate and graduate studies in education*. The Title XI program, added in 1964, authorized *inservice teacher institutes in a variety of subjects other than math and science* (under the

[68] Victor L. Willson and Antoine M. Garibaldi, "The Effect of Teacher Participation in NSF Institutes Upon Student Achievement," Research Paper No. 10, University of Minnesota, Minneapolis, MN, 1974, p. 1.

[69] Congressional Research Service, "The National Science Foundation and Pre-College Science Education: 1950-1975," report prepared for the Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, U.S. House of Representatives, Committee Print, 94th Congress, 2d Session (Washington, DC: U.S. Government Printing Office, January 1976), p. 207.

[70] K. Forbis Jordan, "Precollege Science and Mathematics Education: Experiences with the National Defense Education Act and the Teacher Institutes Conducted by the National Science Foundation," Congressional Research Service, Library of Congress, Report No. 82-214 S, December 1982, p. 19.

[71] Willson and Garibaldi, op. cit., footnote 68, p. 14.

[72] Jordan, op.cit., footnote 70, pp. 19-20.

From 1958 through the 1970s, the federal government supported many workshops and summer institutes to help math and science teachers improve their teaching skills.

purview of NSF). Of particular relevance to technology were the institutes to *train library and educational media personnel. The* NDEA also provided grants for schools to acquire laboratory equipment and authorized a program of experimentation in educational television, radio, motion pictures, and similar media; teacher training was not supported to any meaningful degree under these two programs.

Another federal program relevant to educational media and technology was Title II of the Higher Education Act of 1965, which provided *preservice and inservice training for librarians,* including school librarians; this program still exists in modified form. The Higher Education Act also inaugurated a program of *graduate fellowships in educational media.* A 1969 study concluded that the federal programs for media specialists and library training, along with the programs for instructional media for children with disabilities discussed below, encouraged institutions of higher education to revise their instructional media courses to incorporate material on television and computers and helped increase the use of instructional media in the classroom.[73]

A far-reaching federal effort to reform teacher education was the Education Professions Development Act of 1%7 (EPDA), characterized by some as "the peak involvement of the federal government in teacher education."[74] This legislation sought to coordinate and expand personnel training at all levels by combining existing and new federal teacher programs into

73 U.S. Office of Education, *The Education Professions: A Report on the People Who Serve our Schools and Colleges--1968* (Washington, DC: U.S. Government Printing Office, 1969), p. 182.

74 David L. Clark and Robert F. McNergney, "Governance of Teacher Education,'' *Handbookof Research on Teacher Education,* W. Robert Houston (cd.) (New York, NY: Macmillan, 1990), p. 101.

a single legislative package. Among its components were *programs for professional development for vocational education teachers*, new *fellowship opportunities to encourage advanced training in educational television and radio* and *to prepare instructional media specialists*.

To oversee the EPDA programs, a new Bureau of Educational Personnel Development was established in the Office of Education. Implementation of the act was hampered, however, by dissent about its purposes, contention over its administration, limited funding in light of expectations, lukewarm support from Congress, omission of several specialized training programs from the act's coordinating functions, and diffusion of resources across too many programs. A decade later, all the EPDA programs had been repealed except the Teacher Corps, and it was years before Congress again considered comprehensive reform legislation for teacher training.

The Teacher Corps program, established by the 1965 Higher Education Act then subsumed under the EPDA, was a comprehensive and intensive effort to revamp teacher training and also fill teacher shortages in low-income areas. The program recruited young college graduates who otherwise may not have become teachers to teach in teams in low-income schools under the guidance of experienced teacher-leaders. The program sought to provide teachers-in-training with more meaningful field experiences, to incorporate innovative strategies from the latest research, and to strengthen linkages among school districts, higher education institutions, and communities. Although it did not specifically address technology, it is important because it trained over 61,000 education personnel and over 10,000 interns[75] and pioneered strategies that are now commonplace, including field-based preparation, team teaching, flexible grouping, individualized instruction, multicultural education, community-based education, and collaborative decisionmaking.[76]

Special Education Personnel and Technologies[77]

The federal government played a unique role in the training of special education personnel, one that was much more influential and more receptive to the use of educational technology than the federal role in general teacher training. In fact, it was the need to prepare teachers to work with mentally retarded children that prompted the federal government to become involved in special education in the first place.

Federal support for special education personnel development began in 1958 with a program of *grants to states and higher education institutions to train teachers and other specialized personnel to educate mentally retarded children*. Initially this was viewed as a short-term endeavor, but as the federal government broadened its commitment to special education and later mandated free public education for all handicapped children, it became clear that special education personnel training would be a major and continuous undertaking.

Federal attention and funding produced swift and noticeable impacts: rapid growth in the number and capacity of university and state training programs, an equally rapid increase in the number of specialists equipped to teach handicapped children, and improvements in the quality of training offered.

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[75] U.S. Department of Education, Office of Educational Research and Improvement, *An Overview of the Teacher Corps Program, 1965-1982*, n.d., pp. 22-25.

[76] Jerome Freiberg and Hersholt C. Waxman, "Changing Teacher Education," *Handbook of Research on Teacher Education*, W. Robert Houston (ed.) (New York, NY: Macmillan, 1990), pp. 617-635.

[77] This discussion is based on Richard P. Holland and Margaret M. Noel, *A Review of Federal Legislation Concerning Special Education Personnel Preparation, Technical Report* (College Park, MD: University of Maryland, 1985); U.S. Department of Health, Education, and Welfare, *A Summary of Selected Legislation Relating to the Handicapped, 1963-1967* (Washington, DC: U.S. Government Printing Office, 1968); and U.S. Office of Education, *The Education Professions*, op. cit., footnote 73.

BOX 6-6: Early Federal Support for Training Special Education Teachers in Instructional Media and Technology Applications

The federal movement to make instructional media more available to disabled persons began in 1958 with enactment of a free loan service of captioned motion pictures for deaf persons. The popularity of this program highlighted the urgent need for better dissemination and personnel training in special education media.

In response, two types of centers were created. A network of Special Educational Instructional Materials Centers (IMCs), begun in 1964, collected materials for special education and offered conferences, workshops, institutes, and ultimately university credit courses to train teachers in their use. A parallel network of Regional Media Centers (RMCs) established in 1966 did much the same for media materials for deaf persons.

In 1968 these two types of centers were merged into an IMC/RMC network that experimented with film, television, audio, typewriting, and even computer technologies—as well as more conventional materials—for all types of handicapped persons and that provided related inservice and preservice training. A National Center on Educational Materials and Media for the Handicapped collected and disseminated information about materials and related media training.

By 1974, about 15,000 teachers had been trained in media and materials through these federal programs. Together these programs helped promote wider use of a range of educational technologies, with benefits for both handicapped and nonhandicapped learners. In 1986, the authorizations for all activities related to media, materials, and technologies for special education were grouped under a new Part G of the Education of the Handicapped Act (EHA), the flagship federal law for special education enacted in 1970. This law has now been replaced by the Individuals with Disabilities Education Act.

SOURCES: LeRoy Aserlind, "The Special Education IMC/RMC Network," Educational Technology, vol. 10., No. 8, August 1970, pp. 32-39; S.C. Ashcroft, "NCEMMH A Network of Media/Material Resources, *Audiovisual Instruction,* vol. 21, No. 10, pp. 46-47; William D. Jackson, "The Regional Media Centers for the Deaf," *Educational Technology,* vol. 10, No. 8, August 1970, pp. 45-48, and Malcolm J. Norwood, "Review of Media Services and Captioned Films," *American Annals of the Deaf,* vol. 119, No. 5, October 1974, pp. 460-465.

During the early 1960s, Congress expanded personnel preparation programs to *address other disabilities in addition to mental retardation* and to *cover all levels of inservice, undergraduate, and graduate preparation.* In 1966 the federal government enacted a major state grant program for special education, which included a Part D devoted solely to personnel development.

Developing along a parallel track, the federal government initiated several activities to furnish educational media to help deaf and blind children learn (see box 6-6). These programs included substantial training components and pioneered several innovative uses of technologies.

1 Technology Research, Development and Innovation

NSF was an early leader in developing educational technology and exploring effective ways to help teachers implement it. From 1968 to 1981, precollege technology projects received between 1 and 3 percent of NSF's annual science education budget.[78] *For example, the Precollege Teacher Devel*

[78] For a more complete description of the history of federal support for technology at the K- 12 level, see U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning, OTA-SET-379* (Washington, DC: U.S. Government Printing Office, September 1989), especially pp. 151-171.

opment in Science Program supported teacher institutes, predominantly for secondary school teachers, in improving the teaching of science. Many of these institutes in the late 1970s supported teacher training in computer literacy and emerging technology applications.

The Office of Education (OE), which later became the Department of Education, had an on-and-off relationship with educational technology. As early as 1967, for example, a few **Title I projects** were using educational television to deliver services to disadvantaged children, and as early as 1969, some Title I projects were pioneering computer-assisted instruction. In at least some cases, these projects trained teachers to implement these technology-based approaches. Little information is available about the nature and extent of these experiments; it appears that the training was short and largely focused on how to use specific television or computer programs with Title I students.[79]

Another early stimulant of technology innovation was the original 1965 **Title III of the Elementary and Secondary Education Act**, which made competitive grants to school districts to demonstrate the feasibility of a wide range of educational innovations. Inservice training was a key strategy for local implementation of Title III projects. As noted by a major study of sustained change in Title III and other federal innovation programs, "successful change agent projects seemed to be operating as staff development projects."[80] Title III was also a pacesetter in piloting educational applications of television, computer, and other technologies and in some cases providing teacher training in or with technology. One 1968 Title III project in rural New Hampshire, for instance, trained art teachers through televised in-service courses produced jointly by a university and a school district.[81]

The *Regional Educational Laboratories and Educational Research and Development Centers* that took shape with federal funding in the 1960s also helped expand the knowledge base in teacher education, promote redesign of professional development strategies, and explore educational applications of technology—roles that they continue to play today. In the 1960s, the Labs and Centers were early promoters of educational television, and experimented with using this medium to deliver professional development, until studies showing limited impact dampened enthusiasm. Several years later the introduction of computer instructional technologies revitalized the role of the Labs and Centers in educational technology research and development.

Between 1965 and 1971, OE drew upon the resources of more than 100 discretionary programs to channel $160 million into more than 500 computer-related projects. This scattershot approach fell short, though, according to then U.S. Commissioner of Education Sidney Marland, because it failed to produce a coherent body of knowledge about effective uses of educational technology.[82]

During the next decade, between 1971 and 1980, the federal government spent about $350 million on projects for educational technology, according to one study. If support for educational broadcasting and school audiovisual equipment is included, the figure is over $1 billion. About half

[79] Betsy Mynhier, "The Impact of Federal Programs on Learning to Read in Appalachia," paper presented to the International Reading Association conference, Kansas City, MO, April 30-May 3, 1969; Pittsburgh Public Schools, *ESEA Title I Projects Evaluation Report 1967, Volume II* (Pittsburgh, PA: Pittsburgh Public Schools, 1967); and W. Paul Street, "Computerized Instruction in Mathematics Versus Other Methods of Mathematics Instruction Under ESEA Title I Programs in Kentucky," *Bureau of School Services Bulletin*, vol. 45, No. 1, September 1972.

[80] Paul Berman and Milbrey W. McLaughlin, *Federal Programs Supporting Educational Change: The Findings in Review* (Santa Monica, CA: The Rand Corporation, 1975), cited in McLaughlin and Berman, "The Art of Retooling Educational Staff Development in a Period of Retrenchment," Rand paper series P-5985, 1977, p. 2.

[81] New Hampshire Supervisory Union 21, "Inservice Teacher Education Courses in Art and Science for the Elementary Teachers of New Hampshire: An Evaluation Report," n.p., 1968.

[82] U.S. Office of Education, *The Education Professions*, op.cit., 73, p. 182.

the funding came from large grant programs, such as ESEA's Title I, Title IV-B (for library books and instructional materials and equipment), and Title IV-C (for educational innovation). The remainder came from small discretionary projects with a technology focus.[83] An unidentified portion went toward technology-related teacher training.

In the early 1980s, ED supported *PreCollege Teacher Institutes in Science* for elementary school teachers. Some of these projects trained elementary teachers in computer applications, before the program was consolidated into Chapter 2 block grants. (Chapter 2 consolidated several other teacher training authorities, most notably the Teacher Corps and the Teacher Centers.)

Although the block grant concept meant that no new discretionary programs were funded during this era, then Secretary of Education Terrell Bell promoted his *Secretary's Technology Initiative* aimed at pulling all technology-related projects in the Department under one umbrella. (Funding and program authorizations remained separate, however.) Teacher training to support technology use was authorized in most of these projects, but was not the primary goal. When William Bennett became Secretary of Education, the technology initiative and related emphasis on computer activities ended, remaining a low priority throughout the 1980s.

Educational Television[84]

Commencing with the *NDEA educational television program*, federal funding was instrumental in building the infrastructure and developing programming for educational television; occasionally some of this funding was spent on training the educators to use this technology effectively.

One of the best-known efforts was the Children's Television Workshop (CTW). Beginning in 1968, the Workshop received funding through the Cooperative Research Act and other OE discretionary authorities to develop a variety of education programs, "Sesame Street" being the best known. As a part of this contract, CTW developed curricular materials, teacher guides, and teacher workshops to encourage the use of "Sesame Street" in the classroom.

A federal educational television effort with a rockier history was the Emergency School Aid Act (ESAA) of 1972. This legislation provided grants to school districts that were undergoing school desegregation. At least 3 percent of the funds were reserved by law for grants to public and private nonprofit organizations to produce, promote, and distribute racially and ethnically integrated children's television programming with an educational mission. Between 1972 and 1979, the former Department of Health, Education, and Welfare (HEW) invested nearly $68 million in the ESAA-TV effort, which yielded 31 series. A national evaluation criticized the program for devoting little funding or attention to facilitating classroom use of the television series; the study recommended better teacher materials and followup.[85] Part of the problem was that OE discouraged the use of ESAA-TV funds for inservice teacher training.

[83] Andrew Zucker, "Computers in Education: National Policy in the USA," *European Journal of Education*, vol. 17, No. 4, 1982, pp. 401-403; and Andrew Zucker, "Support of Educational Technology by the U.S. Department of Education, 1971-1980," *Journal of Educational Technology Systems*, vol. 10, No. 4, 1981-82, p. 309.

[84] This discussion is based on Cynthia Char and Jan Hawkins, "Charting the Course: Involving Teachers in the Formative Research and Design of the Voyage of the Mimi," *Mirrors of the Mind: Patterns of Experience in Educational Computing*, Roy D. Pea and Karen Sheingold (eds.) (Norwood, NJ: Ablex Publishing Company, 1986); M. Jay Douds, "The Reshaping of an Innovation: ACSN—The Learning Channel," Appalachian Regional Commission, Washington, DC, 1982; Keith W. Mielke et al., *The Federal Role in Funding Children's Television Programming, Volume 1, Final Report* (Bloomington, IN: Institute for Communication Research, 1975); Bernadette Nelson et al., *Assessment of the ESAA-TV Program: An Examination of Its Production, Distribution, and Financing* (Cambridge, MA: Abt Associates, 1980); and Zucker, op cit., footnote 83.

[85] Nelson et al., op. cit., footnote 84, p. 7.

Yet another relevant program was funded by HEW in 1974 through 1976—a *telecommunications demonstration using NASA satellites*, with projects in Appalachia, the Rocky Mountains, and Alaska. The Appalachian project made particularly strong use of this technology for teacher inservice. Accredited teacher training courses in reading and career education were developed by the University of Kentucky and transmitted throughout the region, with opportunities for live discussion. This demonstration grew into an educational cable network that continued teacher-oriented programming.

More recently, ED and NSF dollars helped develop "The Voyage of the Mimi," a science and math educational television series for classroom and broadcast use that first aired in 1984 and that included companion multimedia teacher materials. Teachers served as consultants and field testers in the development of the curriculum and helped designers determine what training teachers needed to use the series effectively. Distributors were required to provide teacher training, which was done through school-based workshops and sessions at teacher conventions.

Impact of Past Federal Programs

An ever-changing roster of programs and variable funding levels makes it hard to trace long-term effects of prior federal teacher training programs in technology. In addition, programs differed so much in structure, content, and intensity that there are few common bases for generalizations.

Many programs did not conduct adequate, timely, or objective evaluations; often there was no funding reserved for this purpose. Few conducted formal evaluations or control-group studies assessing changes in teacher behavior or student outcomes. When evaluations were conducted, they were often little more than surveys of participants' reactions to training activities. Furthermore, there was often no clear consensus about which goals and outcomes were most important or worthy of assessment. And when evidence of teacher or student outcomes did appear, it was hard to attribute it definitively to a particular federal program because of the myriad influences that affect teaching and learning.

The studies that are available look at the entire teacher training program and do not single out technology-related aspects. Still, their findings have implications for the more focused technology training efforts underway today.

Evidence is available regarding several outcomes of federal teacher training programs in a wide number of areas: numbers and kinds of participants affected; knowledge and skills acquired by teachers; changes in instructional methods and teacher effectiveness; effectiveness of teacher-leaders in reaching peers; improvements in student learning and attitudes; adoption and impact of model programs; and changes in institutional behavior, organizational structures, and strategies for teacher education. Based on these measures, results are mixed.[86] The federal government had a clear and positive impact on some of these goals and a negligible or uncertain impact on others. Moreover, impact and effectiveness varied enormously from program to program, and from site to site. And in some cases, federal programs had undesirable negative side effects. These positive and problematic outcomes are summarized in box 6-7.

LESSONS FROM PAST AND PRESENT FEDERAL EFFORTS

The history of federal programs in support of teacher preparation and professional development over 40 years holds several lessons that ought to be considered in forging future policy. **Many different approaches to improve teacher training have already been tried, leaving a record that can be plumbed before the same strategy is tried again.**

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[86] See, e.g., U.S. Congress, General Accounting Office, *Precollege Math and Science Education: Department of Energy's Precollege Program Managed Ineffectively,* HEHS-94-208 (Washington, DC: September 1994).

BOX 6-7: Summary of Impacts of Federal Teacher Development Programs

Positive Outcomes of Past Federal Teacher Development Programs

- *Participation in federal training programs produced substantial improvements in the knowledge, attitudes, behavior and career advancement of many teachers.*

  For example, participants were more likely to experiment with new approaches, use technology more appropriately, use a wider variety of teaching techniques, and become more involved in school and community educational policy issues.[1]

- *Participants perceived that federal programs had positive effects at the institutional level.*

  For example, teacher education institutions added new courses, strengthened collaboration with parents, students or the community, improved "learning by doing" and by competency-based approaches, and improved or extended their student teaching opportunities. Most felt that their graduates were better prepared as a result.[2]

- *At the school district level, federal funding sometimes provided the external stimulus needed to promote change.*

  For example, training familiarized many teachers with innovative instructional approaches and integration of technologies such as audiovisual materials, educational television, and computer technologies.

- *Common goals reinforced across federal programs had a greater influence on practices.*

  For example, attention to science and math education over four decades and across many federal programs infused more discipline-specific content into teacher preparation and inservice programs. Emphasis on children with special needs heightened attention to instructional issues for these children in all teacher preparation and inservice programs.

[1] Roy A Edelfelt, Ronald G Corwin, and William I, Burke, "The Impact of Federal Funding for Research and Demonstration on Teacher Education, " *Handbook of Research on Teacher Education,* W Robert Houston (ed.) (New York Macmillan, 1990), pp. 176-177.

[2] Preston M Royster and Gloria J. Chernay, "Teacher Education: The Impact of Federal Funding" (ERIC ED 218218, 1981), pp. 169-177 Another survey of federal Impacts conducted in 1988 corroborated some of these findings Over 70 percent of the respondents believed that federal programs were responsible for many significant new practices in teacher preparation, and a majority felt that teacher preparation had become more practical because of federal programs. Edelfelt, Corwin, and Burke, op. cit., footnote 1, p 175.

(continued)

Why hasn't federal government support resuited in greater long-term changes in teacher preparation and professional development? Several characteristics of federal programs appear to hamper effectiveness and mitigate against sustained change.

Teacher preparation and professional development have been relatively low federal priorities to date. The total funding for all programs specifically targeting teacher-training pales in comparison to such high-priority programs as Title I/Chapter 1, Pen Grants and other student aid, and state grants for children with disabilities. The optional nature of many teacher training authorities has made the past federal attention to teacher development issues ring somewhat hollow.

Federal efforts to influence teacher training have been diffuse and uncoordinated. Federal policy has been carried out through dozens of discrete programs. Somewhere in the history can be found something for almost every purpose: teacher quantity, teacher quality, subject matter knowledge, pedagogical knowledge, the best teachers,

BOX 6-7 (cont'd.): Summary of Impacts of Federal Teacher Development Programs

Problematic Outcomes of Past Federal Teacher Development Programs

- *Most did not seem to yield long-term change.*
  For example, most projects reverted back to former practices after the grant ended;[3] school of education programs were particularly resistant to sustained change. Some deans and others at institutions of higher education were unconvinced that programs led to improvements in faculty teaching, better supervision of practicum experiences, and Incorporation of research findings into teacher preparation.[4]
- *Budget decisions were not always linked to project evaluations.*
  For example, the Department of Energy's Precollege Math and Science Education program did not evaluate half of its most resource-intensive projects, while other evaluations were of poor quality. As a result, many decisions to increase budgets or manage projects were based on inadequate information.[5]
- *Federal programs have not usually reached beyond a small fraction of the total teaching force.*
  For example, most programs have targeted subsets of teachers (e.g., math and science), while in the humanities and other subjects, the impact is much less significant and, in some discipline's, negligible. The Inclusion of special needs students into regular classes creates critical demands for training but federal programs are meeting only a portion of the demand for specialists, and meeting very little of the need to train regular classroom teachers to use educational technology effectively with special needs children.
- *Involvement in multiple programs created some undesirable side effects at the local level.*
  For example, programs have expressed concern with complex and bureaucratic regulations, deficient monitoring procedures, a short-term project mentality, hasty procurements, inadequate resources, and lack of coordination among federal agencies and programs.[6] Problems arose when goals and operational requirements of various programs did not mesh well with each other or with the core local educational program, producing a clash in teaching methods or inhibiting a hollistic approach to staffing and instructional methods.[7]

[3] Roy A. Edelfelt, "The Impact of Federal Funding on Teacher Education, " *Educatioonal Horizons, vo. 67, No. 1-2,* fall-winter 1989, p 49

[4] Edelfelt, Corwin, and Burke, op cit. footnote 1, p 177

[5] U S Congress, General Accounting Office, *Precollege Math and Science Education Department of Energy's Precollege Program Managed Inefficiently HEHS-94-208* (Washington, DC September 1994)

[6] Edelfelt Corwin, and Burke op cit. footnote 1, pp. 177-178

[7] Jackie Kimbrough and Paul T. Hill, *The Aggregate Effects of Federal Education Programs* (Santa Monica, CA: The Rand Corporation, 1981)

SOURCE Off Ice of Technology Assessment, 1995

teachers most in need of improvement, preservice, and inservice have all been "priorities." Limited funding has been spread across many different goals. What has been lacking is a unifying philosophy or an overall policy strategy.

Coordination has been a particular problem, beginning with the early years when both NSF and OE were operating teacher institutes. Attempts to bring more coherence have not been very successful, often because aspects of the legislative process undermined them.

Federal attention to and support for teacher preparation and professional development has been sporadic and lacking in continuity. Programs have come and gone, waxed and waned, in response to the latest perceived crisis or the most recent data on teacher supply and demand. Laws have been enacted that have never been funded,[87] funded inadequately, funded late, or funded for just a few years. This mentality has hindered meaningful and sustained commitment required to solve substantial national problems.

Many programs were "disrupted by fickle political forces" before they were able to achieve momentum,[88] and others were discontinued for political reasons even when they seemed to be working. The lack of deep interest in teacher training issues in Congress has been reinforced by the indifference of the public to teacher needs. Administration support has been variable and often weak, and advocacy by those with a direct interest has not always been successful.[89]

Many programs have had goals that were too ambitious, in light of their funding levels, project periods, or chosen strategies. Filling teacher shortages, reforming schools of education, and training regular classroom teachers to work with children with disabilities are examples of ambitious goals that would seem to necessitate sustained federal attention, considerable resources, and well-designed strategies. Yet these factors have seldom been present. The rhetoric accompanying new federal initiatives sometimes promised "more than [was] possible within the limits of the existing knowledge base, technology, and resources."[90] Often programs were expected to accomplish too much too quickly, or tried short-term solutions to persistent problems.[91]

With some exceptions, such as the Teacher Corps, federal programs have tended to operate at the margins, avoiding the larger state, local, and institutional policies and organizational issues affecting teacher preparation and professional development. The most common mode of training has been a short-term institute or workshop in the context of a specific project—the type of effort that could be easily marginalized by the sponsoring institution. Less frequently have projects addressed local factors found to be associated with sustained changes. The Rand Change Agent study noted that two of the most important factors influencing longer-term change were institutional support from administrators and a well-considered local implementation strategy, yet these factors were lacking in many of the programs examined.[92]

Insufficient funding and attention has been devoted to evaluation. Most past programs did not conduct evaluations needed to determine classroom impact or national impact or discern which practices were most effective. Some programs had no national or formative evaluations, and some did not even have descriptive assessments. When evaluations were conducted, they were not always used to improve programs in subsequent years.

Many of these problems persist. The quality, extent, and timeliness of evaluation practices vary

[87] Even today Title V of the Higher Education Act authorizes several programs focused on teacher preparation and professional development that have never received appropriations.

[88] Roy A. Edelfelt, Ronald G. Corwin, and William I. Burke, "The Impact of Federal Funding for Research and Demonstration on Teacher Education," *Handbook of Research on Teacher Education*, W. Robert Houston (ed.) (New York: MacMillian, 1990), p. 183.

[89] David H. Florio, "Federal Policy and the Improvement of School Personnel," *Viewpoints in Teaching and Learning*, vol. 54, No. 4, October 1978, pp. 154-155.

[90] Edelfelt, Corwin, and Burke, op. cit., footnote 88, p. 182.

[91] K. Forbis Jordan and Nancy B. Borkow, "Federal Efforts To Improve America's Teaching Force," Congressional Research Service, Library of Congress, L.B. 2842 A, March 1984, p. 2.

[92] Berman and McLaughlin, op. cit., footnote 80, pp. 2-3.

substantially among current science, math, engineering, and technology education (SMET) programs.[93] Practices run the gamut: formal evaluations, descriptive reviews, case studies, self-evaluation questionnaires, or anecdotal reports.

A federal interagency review found that of the 116 federal programs for K-12 science, math, engineering, and technology, only 30 (or about one in four) had been evaluated.[94] "For a majority of federal SMET programs, no evaluation information is available at all, or no serious inquiry beyond anecdotal or self-reported data has been made."[95] The review further found that less than one-half of 1 percent of the budgets of the relevant programs was spent on evaluation.[96] As a result, federal programs often lack a rational basis for strategic planning decisions or spending decisions.

The impact of "demonstration" programs intended to produce effective models that can be replicated often has been limited by inadequate funding, variable quality, lack of evaluation, or inattention to administrative mechanisms to promote wide-scale dissemination. Many past and present "demonstration" projects have not developed approaches that are particularly innovative or exemplary, and many do not have very effective dissemination strategies. A federal interagency committee found that in federal SMET programs, less than 1 percent of the funding was used for dissemination. "Valuable education resources developed with federal funding . . . have not been shared effectively," the committee concluded, recommending improved dissemination and better "marketing" of programs to target particular audiences (see box 6-8).[97]

This situation is improving, however. Steps have been taken to improve dissemination through the Eisenhower National Clearinghouse and Regional Consortia, through new multipurpose technical assistance centers authorized by the 1994 ESEA amendments, through guidelines for the Teacher Enhancement program, and through several technology-based initiatives.

There has been little attention to the continuum and interaction between preparing new teachers and enhancing the skills of those already on board. Again, based on supply and demand, federal support has been focused at some periods of time on preservice and at others on inservice teacher development, usually one at the expense of the other. In general, more support and attention have been focused on upgrading the skills of teachers already in the classroom, rather than on developing new teachers through support for schools and colleges of education, signaling what may be a short-sighted approach to influencing teacher quality in American schools.

KEY ISSUES FOR FUTURE FEDERAL POLICIES FOR TECHNOLOGY-RELATED TEACHER DEVELOPMENT

As the executive branch proceeds to implement the major educational technology legislation passed by the 103d Congress, it is useful to identify some issues to be addressed to improve existing programs and effectively carry out new ones. Federal leaders now have the tools to expand and greatly improve technology-related teacher devel-

[93] Federal Coordinating Council for Science, Engineering, and Technology, Committee on Education and Human Resources, *The Federal Investment in Science, Mathematics, Engineering, and Technology Education: Where Now? What Next? Executive Summary* (Washington, DC: June 1993), p. 31.

[94] Federal Coordinating Council on Science, Engineering, and Technology, *Sourcebook*, op.cit., footnote 8, p. 62.

[95] Federal Coordinating Council for Science, Engineering, and Technology, *Executive Summary*, op.cit., footnote 93, p. 29.

[96] Ibid., p. 6.

[97] Federal Coordinating Council on Science, Engineering, and Technology, *Sourcebook*, op.cit., footnote 8, p. 11.

BOX 6-8: Factors Associated with Greatest Impact in Prior Federal Teacher Development Programs

Research on sustained change in federally funded projects found that the projects that produced the greatest impact on teacher change tended to share the following administrative features:

- a sharp focus on an area where strong federal leadership could make a difference,
- teacher training as their primary purpose,
- consistent and adequate funding over several years,
- clear and realistic program goals, and
- willingness to change in response to evolving needs and evaluation findings.

Furthermore, at the project level, the following characteristics seemed to be associated with success:

- well-defined objectives,
- more intensive training experiences,
- ownership and commitment among teachers,
- relevance to teacher needs and everyday concerns,
- varied and flexible training format,
- practical and hands-on training experiences,
- an emphasis on individual and small group learning,
- parity among participating institutions,
- active support of administrators, such as deans or principals,
- regular opportunities for planning during all phases of the project, and
- concrete staff training throughout the project.

SOURCES Dale Mann, "The Politics of Staff Development, " paper prepared for the Annual Conference of the American Educational Research Association, Washington, DC, Mar. 31, 1975, pp. 14-16; Paul Berman and Milbrey W McLaughlin, *Federal Programs Supporting Educational Change: The findings in Review* (Santa Monica, CA: The Rand Corporation, 1975), cited in McLaughlin and Berman, "The Art of Retooling Educational Staff Development in a Period of Retrenchment, " Rand paper series P-5985, 1977, pp. 2-3, and Donald C. Orlich, "In-Service Education: Fiscal Implications for *Policy-Makers," Planning and Changing,* vol. 13, No 4, winter 1982, p. 215.

opment. For example, many critical issues could be addressed in the long-range educational technology plan being prepared by ED.

Implications for long-term legislative improvements should also be considered.

■ Setting Priorities

A critical set of issues revolves around how to give more focus to a diffused federal role. Since there is unlikely to be adequate funding to meet the technology-related training needs of all U.S. teachers, and since the role of the federal government in support of teacher preparation and professional development is a limited one, it makes sense to establish some priorities for federal support.

An ongoing question is whether federal programs should try to serve many teachers and districts, asunder the Eisenhower program, or to demonstrate national models for teacher training that could be picked up by other districts, as in the NSF Teacher Enhancement program, or both. Another way to frame the choice is whether to support only the best new ideas and those schools and districts ready to move ahead with them, using them as models for others; or to help districts and teachers who have the most urgent technology-related training needs. Findings from current studies suggest that the two types of programs—focused demonstration programs and broad service programs—play different and complementary roles,[98] and that there may be a continued need for both. Demonstration programs generate more intensive and innovative strategies and can lead the way for comprehensive reform; but broad service programs are necessary to build awareness among large numbers of teachers. The 1994 amendments continue both strategies. However, in practical terms, it may be difficult to do both. Broad-based support may be so expensive that funding is shallow and diffuse, seeding the field so thinly that a rich outcome is unlikely. Providing comprehensive training at a level that could make a significant difference is likely to be beyond the range of available funding. For example, a study of the Eisenhower program in 1991 suggests that the sustained training endorsed in that study would cost roughtly $890 a year per participating teacher. Extending this model to provide training in educational uses of technologies for the entire K-12 teaching force would be substantial—reaching a quarter of all precollege teachers a year with this level of training would cost approximately $1 billion year.[99] Yet equity concerns may argue against focusing efforts on the already well-positioned, even if leaders can have a broader impact by sharing their experiences with others. In making recommendations, the federal educational technology plan may need to take a clearer stance on this issue.

A related key issue is what kinds of teachers should have priority for technology-related training. Should resources concentrate on supervisors and teacher-leaders, or on those most in need of improvement? On math and science teachers, since technology applications are proceeding rapidly in these fields, or on humanities and other fields, since they have been somewhat neglected to date? On specialists who work with children most at-risk, or on "regular" teachers who work with all children? On elementary or secondary school teachers? Preservice or inservice teachers? Faculty in schools and colleges of education? The current federal role tries to cover nearly all of these target groups, although some very superficially.

Also related is the question of which kinds of institutions should receive priority for federal support—local schools and districts serving the inservice needs of teachers already in the classroom, or schools and colleges of education preparing new teachers to enter tomorrow's classrooms. As discussed elsewhere in this report, many colleges and schools of education are behind school districts and individual schools in terms of faculty expertise, technological resources, and understanding of the potential of technology for education. Given the expected growth in the number of teachers needed in the next decade, it may be cost-efficient to support the development of technology expertise in teacher candidates as they prepare to enter the classroom so that less inservice training will be required once they are on board. Furthermore, federal support encouraging greater connection between colleges of education and K-12 schools may result in partnerships benefiting both, as they share their teaching and technology resources and expertise.

Maximizing the Impact of Reform Efforts

The history of federal teacher training efforts suggests that it is very important to address the broader organizational context in which teachers work. This effort begins with the school site as a locus for change, but it does not end there. Equally important in the U.S. educational system are the state and local institutions that have the main responsibility for teacher policies and that must be relied upon to carry out federal priorities from several layers removed.

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[98] Knapp et al., op. cit., footnote 14, p. vi.

[99] James B. Stedman, U.S. Congress, Congressional Research Service Issue Brief, "Information Technologies in Elementary and Secondary Education: Background and Federal Policy Issues," Washington, DC; 1993, p. 14.

A key issue, then, is how to use federal leadership to integrate technology into existing national, state, and local systemic reform efforts—the most obvious being the reforms fostered under Goals 2000: Educate America Act (Public Law 103-227). If effectively implemented, this legislation has the potential to bring about major interrelated changes in teacher preparation, certification, and professional development, as well as curriculum and testing. The standards that emerge will receive high visibility and could set the direction for most education reforms for the rest of the decade and beyond. The 1994 legislation provides a solid framework for coordinating several different efforts around a similar set of goals and standards, if the opportunities are seized.

A related issue is how to improve coordination and interagency strategic planning among the various federal agencies involved in professional development and technology. Improving coordination is one of the new ED leadership responsibilities under Title III of the ESEA.

Focusing on Necessary Services, Activities, and Support

What are the most effective kinds of federal support to help teachers learn about and apply technology? Should funding allow purchase of hardware and software for teacher use, at home or at school, in order to assure access and use of technology? What are the costs of linking up to or using telecommunications networks for continuing support? Typically, these costs have not been covered in training programs but may be essential components for success.

How could access to telecommunications networks change the nature of programs and services available for training teachers? Although most schools today do not have this access, opportunities to connect and use networks are growing. If current trends continue, one of the most significant uses of telecommunications resources will be teacher's professional use—connecting with other teachers, seeking and sharing information, learning and keeping abreast of changes and developments in their fields. If these networks become used more generally, they could significantly change the nature and form of teacher training and professional development in the future.

Leveraging Resources for Improving and Expanding Training Through Technology

Technology itself can play a critical role in leveraging federal resources. Government networks, resource centers, satellite conferences, and video libraries can extend the sweep of ideas, models, materials, and curricula. If the federal government or other entities choose to emphasize the development of national models, this type of dissemination becomes extremely important.

New funding sources (e.g. the Department of Commerce) and collaborative partnerships with other public sector agencies and with businesses in support of shared use networks can leverage scarce federal dollars in areas benefiting education and the broader community. This is one of the important lessons learned from the Star Schools experience.

Telecommunications and networking technologies can extend the duration of training and provide almost continuous followup and support. Options for building these capacities into all federal training programs need to be explored, along with evaluations of the effectiveness of these telecommunications training and support models.

Aggressive research and development is needed to determine which types of education technologies work best in which settings and for which teachers. Another area for research is whether technology-related training is more effective when delivered in the context of a specific subject area or as a general pedagogical technique, or in some combination. However, because the technologies are changing so rapidly, funders should not require that grantees be locked into any one model.

CONCLUSION

Recent authorizing legislation and federal leadership have set the stage for greater emphasis on technology-related teacher preparation and professional development than ever before. Congressional budget concerns and proposed executive branch funding limits, however, could limit the potential of these initiatives. Nevertheless, the problems associated with overlap, lack of information, and erratic and changeable support across a range of programs could be ameliorated by the technologies themselves, which could offer robust and flexible resources for coordinating information and streamlining the delivery and continuing support for teacher preparation and continuing growth. Whether the promise of these new opportunities is realized will depend on federal, state, and private commitment and effective implementation of new proposals.

Appendix A: Boxes, Figures, and Tables

A

Boxes

Chapter 1

Chapter 2

Chapter 3

Chapter 4

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Chapter 6

Figures

Chapter 1

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Tables

B Appendix B: Sources of Survey Data for This Report

During the course of this report, OTA hired three contractors to collect and analyze survey data. This appendix describes the methodology of each contractor report.

Analysis and Trends of School Use of New Information Technologies

Henry J. Becker—March 1994

No original data were collected for this contractor report. Instead, the results of a number of major national surveys of educational technology conducted between 1989 and 1993 were re-analyzed and synthesized. The majority of the analysis comes from three surveys: 1) the United States portion of the 1992 Computers in Education Study of the International Association for the Evaluation of Educational Attainment (IEA), 2) the 1991 National Study of School Uses of Television and Video conducted by the Corporation for Public Broadcasting (CPB), and 3) the 1993 Survey of Member Teachers of the National Education Association (NEA) conducted for the NEA by Princeton Survey Research Associates. For all three studies, this contractor report also profited from reports in progress or technical documents related to these studies. The major features of these three studies and the other four studies used in the analysis are described below. Additional features are shown in table B-1.

The 1992 International Association for the Evaluation of Educational Achievement Computers in Education Study[1]

The IEA survey is the only recent national survey to provide detailed data about computer use in schools, primarily from school-level staff (principals and school computer coordinators) and student respondents, but also with data collected from teachers. The sample of schools, although rather small (571 schools with responses from computer coordinators), was a carefully drawn national probability sample including public, parochial, and private schools stratified by school size, reported student-computer ratio in 1988, size of

[1] Ronald E. Anderson et al., *Computers in American Schools, 1992: An Overview*, International Association for the Evaluation of Educational Achievement Computers in Education Study (Minneapolis, MN: University of Minnesota, 1993).

TABLE B-1: Sources of Data for "Analysis and Trends of School Use of New Information Technologies"

Study	Data about	Nature of data	Date of study	Nature of sample	Response rate	Number of cases
international Association for the Evaluation of Educational Achievement (IEA) Survey-Stage 1	Schools and teachers	Weighted data	Spring 1989	National probability sample, excluded schools with no computers at all, special education schools and primary schools (serving only below grade 4) Sampled elementary teachers grades 3 through 6 and secondary math, science, English, computer education teachers. Includes public and nonpublic schools	76% of schools (computer coordinator), 94% including partial telephone interview, 79% of teachers (weighted); 93% including telephone interviews	999 schools (1 ,227 including partial telephone mterviews), 817 teachers (957 Including partial telephone interviews)
International Association for the Evaluation of Educational Achievement Computers in Education Survey—Stage 2	Schools, teachers, and students in grades 5, 8, and 11	Weighted data	Spring 1992	National probability sample, excluded schools with *no* computers at all, special education schools and primary schools (serving only below grade 4) Sampled elementary teachers, grade 5, and secondary English teachers (grades 8 and 11) Includes public and nonpublic schools	82% of school-level computer coordinators, 72% of teachers, and 74% of students (About 15Y0 of coordinator sample were partial phone interviews)	571 computer coordinators; 500 teachers, and 11,150 students.
Corporation for Public Broadcasting Study of School Uses of Television and Video	Schools and teachers	Weighted data	Spring 1991	National probability sample of public schools (excluding special, vocational, and alternative education) m districts with more than 300 students; teachers of all subjects and grade levels.	90% of schools (principal), 75% of teachers.	1,829 schools; 3,072 teachers; 2,920 with both questionnaires
National Education Association (NEA) Communications Survey	Teachers	Weighted data	Spring 1993	National sample (simple random sample) of NEA members	33% (reported by NEA as 78%. when excluding those not reached by telephone).	1,206 teachers
Market Data Retrieval: '(Education and Technology"	Schools, from district-level data collection	Printed statistics	Fall-winter 1992	Universe of public school districts. Information gathered at district level except followup mailings sent to schools in largest districts.	About 39% of public schools including 68% of schools in the nation's 893 largest districts	3,927 districts representing 31,172 schools.
National Educational Longitudinal Survey (NELS88) "First Followup"	Teachers and 10th grade students	Printed statistics	Spring 1990	National probability sample of 8th graders, two years later (nondropouts), sample of two of four major subject teachers	94% of students attempted m 1990 followup Unknown bias from low base year (1988) school response rate (61 %) 89% of teachers sampled m 1990	20,706 students, 15,908 teachers divided among 4 subjects
Quality Education Data school census	Schools, from district-level data collection	Raw data (no sampling done)	Summer 1992	Universe of public and nonpublic schools Information gathered at the district level	Near 100% but not uniformly collected on each variable	104,000 schools

SOURCE' Henry J Becker, "Analysis and Trends of School Use of New Information Technologies, " Off Ice of Technology Assessment contractor report, March 1994 the metropolitan area community, and district poverty level. Disproportionate sampling was employed to overrepresent schools with larger student bodies and more computers. (Data analysis was performed using case weights to recreate the equal probability sample needed for valid descriptive statistics.) Response rates for different categories of respondents varied from 72 to 82 percent, including some partial telephone interviews. Extensive questions were included about computer-related hardware and software, utilization, processes of decisionmaking, and attitudes. Students reported their own computer experiences and were given a test of computer literacy which was, however, not used in this analysis. The 1992 IEA survey was a second stage of a longitudinal study that began with a similar study (minus the student data) in 1989.

Corporation for Public Broadcasting's 1991 National Study of School Uses of Television and Video[2]

The CPB survey is the only major recent national survey of instructional television and video presence and use in schools. It also is part of a series—in this case, the third conducted by CPB over a 15-year period. At the school level, the CPB survey was several times as large as the IEA computer survey (1,829 schools; 3,072 teachers), but it did not include student-level data. The sample design involved a multistage probability sample of public school districts, schools, and teachers, explicitly stratified by district size and urbanicity, and implicitly stratified by region and district wealth. Districts enrolling fewer than 300 students were excluded from the population sampled. Ninety percent of principals and 75 percent of teachers responded. Superintendents also completed a survey form, but this was not used in this analysis. Principals responded to questions about their school's experience using a variety of broadcast and stored video media and about school-level support for instructional media. Teachers reported about their use of TV and video in classroom instruction and their own personal experience and access to equipment like VCRs and camcorders.

The 1993 Communications Survey of National Education Association Teacher-Members[3]

The NEA survey was of a sample of current teachers from the NEA's national membership roster, and thus excludes teachers from most large city districts and others that do not have NEA as their employee bargaining agent. A total of 1,206 teachers participated in telephone interviews for this study. Excluded from the sample were special education teachers, resource teachers, and those who did not currently teach in grades K-12. The cooperation rate for this survey (i.e., the percentage of eligible sample members reached who agreed to be interviewed) was 79 percent. However, field work was terminated before the majority of initially sampled individuals could be reached. So from a formal standpoint, the response rate for this survey (interviews divided by estimated number of eligible members originally sampled and called) was only about 33 percent. However, the vast majority of the remaining 67 percent were not "refusals," but simply those who were not reached by telephone. In addition, the NEA survey was of limited use because it was not principally about teachers' technology *use* but rather about their *perceptions of access* to technologies. However, it was valuable in that it included

[2] Andrew L. Russell and Thomas R. Curtin, *Study of School Uses of Television and Video: 1990-91 School Year* (Arlington, VA: Corporation for Public Broadcasting, February 1993). Also see Research Triangle Institute, *Study of the School Uses of Television and Video: Methodology Report* (Research Triangle Park, NC: Research Triangle Institute, Mar. 20, 1992).

[3] Princeton Survey Research, *National Education Association Communications Survey: Report of the Findings* (Princeton, NJ: June 2, 1993).

information about both computer and video technologies in the same survey and contained information not otherwise available about access to other technologies such as telephones and photocopying.

Other Survey Sources

In addition to the IEA, CPB, and NEA surveys, substantial information about the presence of technologies in schools was provided by an August 1993 report on the K-12 public school market for educational technology by Market Data Retrieval (MDR), Inc.,[4] and from the master building-level and district-level datasets and related reports from Quality Education Data (QED).[5] Both of these market research surveys supplied data on technology presence (although nothing on utilization), but each had disadvantages that prevented further use. Both market surveys reported data about individual schools but collected these data primarily at the district level, making detailed data less reliable, with impairment most likely in medium-sized and larger districts. It has been accepted for some time, for example, that QED's census of the number of school computers is roughly 25 percent under the estimates obtained using national probability surveys such as those of the IEA Computers-in-Education studies.[6]

Access to the MDR data was limited to published tabulations. Moreover, the MDR survey response rate was very low (roughly 25 percent) except for the largest 7 percent of all districts. Overall, only 39 percent of public schools (no private or parochial schools) were included in the tabulations in the MDR report. The QED dataset, while encompassing more than 100,000 public, Catholic and other private schools nationwide, produced estimates that were at significant variance with similar data obtained from the CPB and IEA surveys—almost always reporting fewer schools having a given type of technology (e.g., videodisc players, modems, integrated learning systems)—even when one attempted to correct MDR results for their disproportionate number of schools from large districts. This almost certainly derives from the QED dataset being composed of accumulated reports over several years and thereby not only undercounting recent acquisitions but providing only partial data about types of technologies more recently added to its database (e.g., presence of CD-ROM). Nevertheless, both QED and MDR tabulations were useful at various stages in the analysis.

Finally, other statistics produced for this contractor report came from both original analysis and published tabulations of teacher and student data from the 1990 "first followup" of the National Educational Longitudinal Survey (NELS88),[7] and from original analysis and tabulations from the 1989 IEA Computers in Education Survey. Use of the NELS88 survey was minimal because only a few questions dealt with technology, and use of the 1989 IEA survey was primarily for providing baseline data for measures of change. The 1989 IEA survey did contain much more detailed data on computer use at the teacher level than any other more recent survey available for this analysis, but because of its age (41/2 years as of this writing), its descriptive statistics on computer use

[4] Market Data Retrieval, *Education and Technology, 1993: A Survey of the K-12 Market* (Shelton, CT: August 1993).

[5] Quality Education Data, *Technology in the Public Schools: 1992-93* (Denver, CO: January 1993), *Educational Technology Trends, Public Schools: 1992-93* (Denver, CO: August 1992).

[6] Ibid., *Technology in the Public Schools: 1992-93,* p. 4.

[7] Steven J. Ingels et al., *National Education Longitudinal Study of 1988: First Follow-Up Teacher Component Data File User's Manual* (Washington, DC: National Center for Education Statistics, November 1992); *National Education Longitudinal Study of 1988: First Follow-Up Student Component Data File User's Manual,* vols. 1 and 2 (Washington, DC: National Center for Education Statistics, April 1992).

were felt to be generally too outdated to be useful.[8]

Those seven surveys—the 1992 and 1989 IEA Computer surveys, the CPB video survey, the NEA member survey, the two market surveys (MDR and QED), and the 1990 NELS first followup survey—constitute the database for the Becker contractor report. Other sources of survey data were considered but excluded on grounds of insufficient national representativeness, unsatisfactory response rate, or lack of timeliness.[9]

State Technology Activities Related to Teachers

Ronald E. Anderson—Nov. 15, 1994

During the summer of 1993, telephone calls were placed to an educational technology coordinator or specialist in all states and the District of Columbia. After repeated calls, responses to a telephone interview were obtained from over 85 percent of the states. In addition, reports of various types related to educational technology were obtained from a majority of the states. A year later, in June 1994, a survey form was mailed to all state educational technology coordinators asking them to update and clarify several technology policy items. During the summer repeated calls, faxes, and mailings were used to obtain responses from all the states as to the accuracy of the information collected.

Information Technology in Teacher Education: Surveys of the Current Status

Jerry Willis, Linda Austin, and Dee Anna Willis—March 1994

A comprehensive survey focusing on the use of information technology—"The USA Faculty Survey"—was mailed to a random sample of teacher educators in the United States. A second survey, reworded for recent graduates of teacher education programs, was sent to a random sample of public and private schools across the United States. This survey—called "The USA Recent Graduate Survey"—was addressed to principals who were asked to forward it to the most recently hired teacher. The only additional requirement was that the teacher who completed the survey must have graduated within the last two years.

Although the survey data presented in this contractor report represents one of the only efforts to date to gather information on technology in teacher education, a number of limitations should be kept in mind. A major limitation is the low rate of return for all of the surveys. The surveys sent to teacher education faculty and recent graduates

[8] Henry Jay Becker, "United States Participation in the I.E.A. Computers-in-Education Study," final report to the National Science Foundation, Grant #SPA-8850564, Center for Social Organization of Schools, Johns Hopkins University, September 1992.

[9] The 1992 survey by Bank Street College, "Telecommunications and K-12 Educators," directed by Margaret Honey (M. Honey and A. Henríquez, "Telecommunications and K-12 Educators: Findings from a National Survey," Center for Technology in Education, Bank Street College of Education, 1993) provides useful information about the most active telecommunications-using teachers, but is based on a purposive snowball sample of high-end users rather than a representative sample of teachers.

Market surveys published in 1991 by LINK Resources Corporation ("K-12 Market for Technology and Electronic Media: Ninth Annual Survey") and in 1992 by the Software Publishers Association ("1991-92 SPA K-12 Market Study Report") both obtained roughly 20 percent response rates from school principals or other school or district officials, deemed insufficient to provide valid enough information about the full population of U.S. schools.

Several statewide surveys have been conducted during the past several years—for example, "Technology in the California Classroom: The Teacher's Perspective 1991," conducted by Robert G. Main for the California Technology Project—but it was decided that state-level statistical information would not be informative for considering national patterns and trends.

Finally, several once-informative national studies are now dated by the rapid rate of change in technology availability and use—among them the 1989 U.S. Census Bureau's supplementary questions on computer use in the October 1989 Current Population Survey, as reported in their publication, "Computer Use in the United States: 1989," Current Population Reports, Series P-23, No. 171, 1991.

were quite lengthy and the time required to complete the survey may have been one factor in the relatively low return rates. Another factor possibly contributing to a low rate of return was that the distribution method involved sending surveys to administrators who were then asked to distribute them to the appropriate instructors. For example, from the 1,223 faculty surveys mailed to teacher education institutions, a total of 250 were usable, which is 20 percent of the surveys mailed. As the percentage of usable surveys was relatively low, readers should be cautioned about over-interpreting the survey data.

The USA Faculty Survey

The faculty survey included questions about the institution and teacher education program, the faculty member's history of general and instructional use of information technology, attitudes toward technology, and ratings of barriers to wider use of information technology. The survey was developed after a thorough review of existing surveys on both K-12 use of technology and technology use in teacher education. Many of the items in the survey used here were based on items in previously published surveys. Once a draft survey was developed, it was evaluated by an advisory group of experts and by OTA staff. The feedback was used to revise the instrument, and experts were again asked to review it. For example, the original instrument was much longer than the final version. It contained items on how faculty used technology rather than simply whether they used it or not. Most of the reviewers felt the original survey was far too long and recommended it be shortened. Many items were removed.

A random sample of 65 teacher education programs was selected from *Peterson's Guide to Colleges and Universities.*[10] The only restriction on randomness was the requirement that all 15 of the largest teacher education programs in the United States be included in the sample. At least one survey was returned from 66 percent of the institutions sampled. A total of 250 usable surveys were returned.

The USA Recent Graduate Survey

The survey sent to recent graduates was a modified form of the faculty survey. The questions were rephrased to indicate the respondents were students in teacher education programs rather than faculty.

A random sample of 500 elementary and secondary schools in the United States was selected by a mailing list organization and supplied to the researchers on mailing labels. Both public and private institutions were included. A total of 100 surveys were returned, a return rate of 20 percent. However, a total of 70 surveys were usable and all the data in this section is based on the analysis of 70 surveys. The 30 unusable surveys were returned because the school had closed or no teacher met the criteria of having competed a teacher education program within the last two years. With only 70 usable surveys, the results should be considered tentative.

[10] *Peterson's Guide to Four-Year Colleges*, 19th Ed. (Princeton, NJ: Peterson's Guides, 1989).

C Appendix C: Glossary

Analog communication
A communication format in which information is transmitted by modulating a continuous signal, such as a radio wave. Voice and video messages originate in analog form since sound and light are wavelike functions; thus, they must be converted into digital messages in order to communicate along digital communications formats or media.

Anonymous FTP site
A **server** that allows the public to log on and download files without having an account or a user ID on that server.

Application tools
Computer software that enables the user to manipulate information to create documents or reports.

Archie
A database listing programs and data files available at anonymous FTP sites or Telnet sites on the Internet. See *Veronica*.

ARPAnet
The original experimental U.S. government network that started the Internet. ARPAnet was started in the mid-1960s to connect researchers, and is no longer in existence. ARPA is the Advanced Research Projects Agency, under the Department of Defense, previously named DARPA (Defense Advanced Research Projects Agency).

Artificial intelligence
The use of computer processing to simulate intelligent behavior. Current research includes natural language recognition and use, problem solving, selection from alternatives, pattern recognition, generalization based on experience, and analysis of novel situations.

ASCII (American Standard Code for Information Interchange)
Pronounced "as-key," a set of computer characters devised to achieve some measure of compatibility among various computers. Putting a text file in ASCII format reduces it to essential elements—upper- and lower-case letters, numbers, punctuation, and some control characters but no graphics characters or printer codes—and eases the process of sharing it with other computers.

Asynchronous communication
Two-way communication in which there is a time delay between when a message is sent and when it is received. Examples include electronic-mail and voice-mail systems. In contrast, synchronous communication is simultaneous two-way exchange of information—for example, a telephone conversation.

Audiographic conference
A conferencing system that can transmit audio and still-video signals, computer graphics, and text on the same telephone cable or other narrowband communications channel. Equipment generally includes computers, graphics cables, and speaker phones at both the receiving and delivering ends.

Authoring
The process of building or modifying computer software using a computer program designed for that purpose. Generally, authoring software applications require less technical expertise compared with programming languages.

Backbone
The main communication channel in a network wiring scheme, so called because other communications lines connect to it like ribs connect to the human body's backbone.

Bandwidth
A measure of information-carrying capability. The difference between the lowest and highest signal frequency is expressed in hertz (cycles per second). Wider bandwidths can carry more information.

BITNET (Because It's Time Network)
An international computer network created to connect research institutions and higher education.

Broadband
A flexible, all-purpose, two-way medium that provides the wide bandwidth necessary for both conventional video and high-definition television, and for still-frame displays for information retrieval, catalog shopping, and so on.

Bulletin board service (BBS)
A computer service that is modeled after a community bulletin board. Using a computer, modem, and phone line, individuals connect to a central "host" computer to post or read messages or to upload and download software. Communication is usually asynchronous.

Cable television system (CATV)
A broadband communications system capable of delivering multiple channels of programming from a set of centralized satellite and off-air antennae, usually by coaxial cable, to a community. Many cable television systems combine microwave and fiberoptic technologies.

CAI (Computer-aided instruction)
Instruction that is carried out or supported by computer technology.

CD-ROM (Compact disc-read only memory)
An optical storage system for computers that permits data to be randomly accessed from a disc. With read-only discs, new data cannot be stored nor can the disc be erased for reuse. Other optical storage systems allow users to record or write and rewrite information.

Chat room
An area on a computer network where members "gather" to type in messages in real time. They can receive immediate responses. There are two types of chat rooms—public and private.

Client
A computer workstation that can request and receive services, information, and applications—such as file transfer to other computers, access to a printer, or access to another computer network—from a server on the same computer network.

Coaxial cable
Shielded wire cable that connects communications components. Coaxial cable is commonly used in cable television systems because of its ability to carry multiple video (or other broadband) signals.

Codec
An electronic device that converts analog video signals into a digital format for transmission, and vice versa. The name is an abbreviation for "coder-decoder," or "compressor-decompressor" when compression is also involved.

Compression
Compressing information so that it requires less space to store or transmit. When speech is compressed, for example, pauses are eliminated. Compression is generally expressed as a ratio. For example, an 8-to-1 ratio means that the information requires one-eighth of its original space. The greater the compression ratio, the higher the chance for loss of quality in image, sound, or motion. In compressed video, digital technology is used to encode and compress the signal. Picture quality is generally not as good as full motion; quick movements often appear blurred.

Computer graphics
Representations of information in formats other than text on a computer. Application tools allow users to draw or "paint" original images with a mouse or a graphics tablet.

Conference
In computer networking, refers to an online discussion group focused on a topic.

Connectivity
The degree or level to which one computer can connect to an online service. For example, a lower-level of connectivity to the Internet may support only the exchange of e-mail, while a more advanced level of connectivity may support FTP and Telnet services.

Courseware
A package used for teaching and learning that includes computer or video software and related print materials such as a teacher's guide and student activity books.

Curriculum (*pl.* curricula)
The courses offered by an educational institution. Most schools have a prescribed curriculum teachers must follow throughout the school year and on which students are tested as the basis for passing a course or getting credit for it.

Cyberspace
Worldwide pool of information stored and transmitted by internetworked computers. William Gibson created the term in his novel *Neuromancer*, where he used it to refer to computers and the society that focuses on them.

Database
A collection of related information, computer databases can include text files, programs, and graphics, that can be searched by key words or other means, and reviewed or downloaded onto another computer.

Digital communications
A communications format used with both electronic and light-based systems that transmits audio, video, and data as bits of information.

Digital video
A format used to store, manipulate, and transmit moving images of bits of information. Codecs are used to convert traditional analog signals into a digital format and back again. Digital video can be compressed for more efficient storage and transmission.

Digitize
To change analog information to a digital format. Once information has been converted to this form, it can be conveniently stored, manipulated, and compressed. It can also be transmitted over a distance with little or no loss in quality. Sound (such as speech or music), still images (such as transparencies), and motion video are commonly converted into digitized form.

Distance learning
Instruction delivered from a distant site, possibly including data, voice, and video transmissions for interactivity.

Distributed network
Network that relies on multiple computers to provide various resources to other computers in the network, rather than making all resources available from a single server. The Internet depends on distributed networking.

Domain
A set of nodes on the Internet whose names share the same last two or three parts. For example, "msu.edu" is the domain name for the network of Michigan State University. Domain names that

end with “edu” are for education organizations; “com” for commercial entities; “net” for networks; and “gov” for governments.

Download
To copy a file, e-mail, or other information from a central computer to a personal computer. See *upload*.

Downlink
An antenna shaped like a dish that receives signals from a satellite. See *uplink.* Often referred to as a satellite dish, terminal, Earth station, or TVRO (television receive-only).

Electronic mail (e-mail)
A computer application for exchanging information over a distance using a modem and a computer. Communication is asynchronous. E-mail typically consists of text and/or graphics; advanced multimedia formats are under development. It can be addressed to an individual, as well as to groups of people.

E-mail address
A specific, locatable, electronic address that designates a person or service at a specific network site. Electronic mail addresses include a user name (which can be a title or function, such as “info”), the symbol “@,” and a domain name (e.g., teacher@school.edu).

Ethernet
A type of **local area network** of up to 1,024 nodes (i.e., computers in a network), originated by Xerox Corporation. It specifies the types of wires connecting the network and the format in which information is packaged to travel over those wires. There are three types of Ethernet connections; different Ethernet systems use different software protocol, such as TCP/IP.

Facsimile machine (fax)
A device that converts hard-copy images and text into an electronic form for transmission over telephone lines to a similar device at another location, which then reconverts it back to text and images.

Fiberoptic cable
Hair-thin, flexible glass rods that use light signals to transmit information in either analog or digital formats. Fiberoptic cable has much higher capacity than copper or coaxial cable, and is not as subject to interference or noise. Fiberoptic cable has the bandwidth to accommodate high-speed, multimedia networking.

File
A file is a body of information (text, graphics, or a program) that can be passed from one computer to another.

File server
The personal computer that provides access to files for all workstations in a local area network.

Flame
To send over a computer network, as through e-mail, a message displaying a derogatory, obscene, or inflammatory attitude.

Flat-panel display
A video or computer screen that is relatively thin, lightweight, and typically used in portable computers.

FreeNet
One of a group of freely accessible servers offering information, e-mail, and access to the Internet over telephone lines.

FTP (File Transfer Protocol)
A standard technique for transferring files among dissimilar computer systems on a network.
A program that transfers files using file transfer protocol. It supports file exchange over the Internet.

Gateway
A dedicated computer that provides a link between dissimilar networks, allowing information to cross between the two.

Gopher
Software that presents in menu form information found all over the Internet. Gopher programs also allow searches on the Internet for hosts, directories, or files based on keywords supplied by the user.

Groupware
A software program that allows the same information to be shared among several computers simultaneously. With some applications, users can see

each other and, from their own computers, add to or edit text and graphics in a single document.

Hardware
The electrical and mechanical equipment used in conjunction with software (programs and files) for computer and telecommunications systems.

Host
The main computer system to which computer users are connected.

Hub
A point of connection to the Internet for users in a particular region.

Hypercard
A software program designed to create multiple pathways for moving through a body of related material, allowing the user to link documents and parts of documents in a nonlinear fashion from a single computer. Words in the displayed document may be linked to other documents or other text in the same document, usually by icons within the document, sometimes called *buttons*. Through Hypercard applications, the user can quickly access linked materials from a variety of media, such as still-motion video from a videodisc linked to a paragraph from a word processor (this type of Hypercard use is often called *hypermedia*).

Icon
A symbol displayed on the computer screen that represents a command or program (e.g., a trash can symbolize the command to delete a document or file).

Information highway/information superhighway
The vast network of interconnected telecommunications systems worldwide.

Interface
A general term used to designate the hardware and associated software needed to enable one device to communicate with another or to enable a person to communicate with computers and related devices. A user interface can be a keyboard, a mouse, commands, icons, or menus that facilitate communication between the user and computer.

Internet
International collection of interconnected electronic networks that support a common set of data communication protocols—Transmission Control Protocol (TCP) and Internet Protocol (IP). Internet evolved from ARPAnet. The National Science Foundation supported wider use of the network through development of NSFnet, expanding and replacing ARPAnet, and through funding for development of regional distribution networks. Many networks in the United States and worldwide are now part of the Internet.

ISDN (Integrated Service Digital Network)
Network that accommodates digital transmission of voice, data, and video over, standard copper telephone lines.

Keyword
A word that leads the user to go directly to a specific area. For example, entering the keyword “LABNET” takes you to the LabNetwork; “NGS,” to the National Geographic Society; “Time,” to *Time* magazine.

Knowbots
Software programs that act as “knowledge robots” to carry out functions such as searches for desired information, on electronic networks.

“Last mile”
Popular term for the last segment of the connection between a communication provider (e.g., telephone company central office) and the customer (usually residential, but sometimes commercial).

LATA (local access and transport area)
A geographic region ranging from a metropolitan area to a state, created with divestiture of AT&T and used to define service areas for regulated versus unregulated services (e.g., intra-LATA local service versus inter-LATA long-haul services).

Library
The term library, when used with computers, refers to a collection of computer files. A library contains files that can be text, graphics, or programs.

Listserv
A program (text and graphics) that distributes e-mail to users on a computer network who share a common interest and whose ID's are stored together. Any mail sent to a list on the listserv is automatically distributed to everyone on that list.

Local area network (LAN)
A network connecting computers in close proximity, LANs facilitate communication and sharing of information and computer resources (such as printers or storage by the members of a group).

Login/Logon/Logoff
The process of entering and leaving an electronic communications system; access generally requires a user identification code or password (often the user's name).

Mailbox
A file or directory on the end user's host computer that holds the user's e-mail.

Mailing list
A topic-specific alias with multiple mail destinations.

Message board
Message boards (or boards) are where members post messages, reply to messages, and so forth. Boards are organized using folders, which contain messages on a specific theme.

Microwave
High-frequency radio waves used for point-to-point and omnidirectional communication of data, video, and voice.

Modem
A device that allows two computers to communicate over telephone lines. It converts digital computer signals into analog format for transmission. A similar device at the other end converts the analog signal back into a digital format that the computer can understand. Abbreviated form of "modulator-demodulator."

Mosaic
A popular interface that eases navigation of the Internet.

Mouse
A pointing device that connects to a computer. With a mouse, users can control pointer movements on a computer screen by rolling the mouse over a flat surface and clicking a button on the device. The mouse is also commonly used to define and move blocks of text; open or close windows, documents or applications; and draw or paint graphics.

Multimedia
Any combination of video, sound, text, animation, and graphic images in a computer-based environment. Often includes technology such as CD-ROM, videodiscs, videocassette recorders, television, video cameras, and software.

National Research and Education Network (NREN)
Electronic network that eventually will succeed the noncommercial aspects of the Internet in the United States.

Network
A shared communications system that supports digital communication among connected computers.

Newsgroup
A topical discussion group on a network. Individuals submit messages to a newsgroup and read messages that are posted there.

NII (National Information Infrastructure)
The overall electronic information system in development in the United States.

NSFnet
The National Science Foundation Network, a high-speed network of networks linking computers at educational and research institutions. It is made up of several regional networks.

Online
Being actively connected to a network or computer system; usually being able interactively to exchange data, commands, and information.

Optical storage
High-density disk storage that uses a laser to "write" information on the surface. Erasable or rewritable optical storage enables written informa-

tion to be erased and new information written on the disk.

PC
A personal computer or microcomputer. The Apple Macintosh and the IBM PS/2 are examples of personal computers. Many participants on the Internet use PCs to connect to Internet hosts.

Point-to-point protocol (PPP)
Protocol that enables a computer to use the Internet protocols (TCP/IP). PPP is gaining in popularity over the SLIP alternative.

Protocols
The set of specific communication standards that allow one computer to interact with other computers.

RAM (random access memory)
Computer memory where any location can be read from, or written to, in a random access fashion. A computer's RAM is its main memory where it can store data.

ROM (read only memory)
Once information has been entered into this part of the computer's memory, it can be read as often as required, but cannot be changed by the user.

Router
A device (sometimes a specialized computer) that stores addresses of network hosts and forwards packets of data between networks. For maximum access to the Internet's resources, a local area network needs its own router.

Satellite
See *downlink*.

Scanner
An input device attached to a computer that makes a digital image of a hard-copy document, such as a photograph, scanned picture, graph, map, and other data that are often used in desktop publishing.

Server
A server is a powerful computer on a network that provides a particular service and information to other computers; for instance, a disk server manages a large disk, and a print server manages a printer.

Shareware
Shareware is software that can be shared among users but it is not free. Users purchase this type of computer software through donations to the software developer, usually to fund further research and development of the product line.

Simulation
Software that enables the user to experience a realistic reproduction of an actual situation. Computer-based simulations often involve situations that are very costly or high risk (e.g., flight simulation training for pilots).

"Snail mail"
Paper-based mail, delivered by the U.S. Post Office or other vendor, that cannot compete for speed with electronic networking.

Software
Programming that controls computer, video, or electronic hardware. Software takes many forms, including application tools, operating systems, instructional drills, and games.

Synchronous communication
See *asynchronous communication.*

Sysop (system operator)
A person in charge of a network system or BBS.

TCP/IP
Abbreviation for Transmission Control Protocol/Internet Protocol. TCP/IP is a set of computer commands that dictate how the computers on the Internet will communicate with each other.

Teleconference
Simultaneous visual and/or sound interconnection using telecommunications links that allow individuals in remote locations to see and communicate with each other in a conference arrangement. There are many types of teleconferencing, including videoconferencing, computer conferencing, and audioconferencing.

Telnet
An Internet service that allows users to log on to remote host computers as "guest" users, providing access to the files as if they were actually at the host site.

Terminal
The computer used to connect to a host. The terminal can be a personal computer such as a Macintosh, IBM, or compatible microcomputer.

Touch screen
A device that attaches to a computer screen that allows data to be entered by using a specialized stylus to write on the screen, or by making direct physical contact between the finger and the screen.

Uplink
A satellite dish that transmits signals up to a satellite. These signals are then sent back to Earth to a downlink (receiving) site.

Upload
To copy a file, e-mail, or other information from one's personal computer to a larger computer on a network.

Veronica
A Gopher service that allows you to do a keyword search of Gopher menus. Named after the comic strip character (like *Archie*).

Videoconference
A form of teleconferencing where participants see and hear other participants in remote locations. Video cameras, monitors, codecs, and networks allow synchronous communication between sites.

Videodisc
An optical disc that contains recorded still images, full-motion video, and sounds that can be played back using a Videodisc player through a television monitor. Videodiscs can be used alone or as a part of a computer-based application.

Videotext
A form of multimedia that presents video and text simultaneously on the same screen.

Voice mail
An electronic system for transmitting and storing voice messages, which can be accessed later by the person to whom they are addressed. Voice mail operates asynchronously, like an e-mail system.

Voice recognition
Computer hardware and software systems that recognize spoken words and convert them to digital signals that can be used for input (often used as an alternative to other input devices, such as a keyboard).

WAIS (Wide Area Information Server)
A protocol that allows users to search and access different types of information on many different computer systems from a single interface. This text-based information retrieval system selects databases from an unlimited pool, without the need for user familiarity with the internal configurations of each, and helps to organize responses on the user's machine despite vast amounts of accumulated data.

Wide area network (WAN)
A computer network in which widely dispersed computers, such as those among several buildings or across a city or state, are interconnected. WANs make use of a variety of transmission media, which can be provided on a leased or dial-up basis.

Window
A part of the computer screen that is given over to a different display from the rest of the screen (e.g., a text window in a graphics screen). It can also be a portion of a file or image currently on the screen, when multiple windows are displayed simultaneously.

Wireless
Voice, data, or video communications without the use of connecting wires. In wireless communications, radio signals make use of microwave towers or satellites. Cellular telephones and pagers are examples of wireless communications.

Workstation
A computer that is intended for individual use, but is generally more powerful (i.e., it has greater memory and speed) than a personal computer. A workstation may also act as a terminal for a central mainframe.

World Wide Web (WWW)
A hypermedia information retrieval system linking a variety of Internet-accessible documents and data files (text and graphics). Often referred to as "the Web."

Appendix D: Workshop Participants, and Reviewers and Contributors

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Note: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the reviewers and contributors. The reviewers and contributors do not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

Appendix E: Contributing Sites

E

Throughout the course of this assessment, OTA received information and assistance from many schools, districts, and educational institutions across the United States. The following is a listing of sites that participated in OTA's case studies, served as the focus for the video report, and were visited by OTA staff.

Case Study Sites

Curry School of Education, University of Virginia and Jackson-Via Elementary School

Peabody College at Vanderbilt University and Carter Lawrence Middle School

University of Northern Iowa and Price Laboratory School

University of Wyoming and The Wyoming Center for Teaching and Learning at Laramie

Bellevue School District
Bellevue, WA

Jefferson County Public Schools
Jefferson County, KY

Monterey Model Technology Schools
Monterey, CA
- Manzita Elementary School
- Martin Luther King Middle School
- Monterey High School
- Ord Terrace Elementary School

The Texas Education Agency
Austin, TX

Video Sites

Central Kitsap School District
Silverdale, WA
- Brownsville Elementary School
- Emerald Heights Elementary School
- Olympic High School
- Ridgetop Junior High School

George Mason University
Alexandria, VA

Lockwood Elementary School
Billings, MT

The Options School, Capital Children's Museum
Washington, DC

Piscataquis Community High School
Guilford, ME

Shelby County High School
Shelbyville, KY

Webster Elementary School
St. Augustine, FL

Other Sites

Ashlawn Elementary School
Arlington, VA

Carver Educational Services Center
Montgomery County, MD

Challenger Center for Space Science Education
Washington, DC

Jefferson Junior High School
Washington, DC

National Demonstration Laboratory
Washington, DC

Science, Mathematics, and Computer Science Magnet
Montgomery Blair High School
Silver Spring, MD

Appendix F: Contractor Reports Prepared for This Assessment

F

Copies of contractor reports done for this study are available through the National Technical Information Service, either by mail (U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161) or by calling NTIS directly at (703) 487-4650.

Ronald E. Anderson, University of Minnesota, "State Technology Activities Related to Teachers," November 1994, 100 p., NTIS No. 95-184800.

Henry Jay Becker, University of California at Irvine, "Analysis and Trends of School Use of New Information Technologies," March 1994, 93 p., NTIS No. 95-170981.

James Bosco, Western Michigan University, "Schooling and Learning in an Information Society," November 1994, 43 p., NTIS No. 95-172227.

Larry Cuban, Stanford University, "Public School Teachers Using Machines in the Next Decade," October 1994, 42 p., NTIS No. 95-172243.

Melinda Griffith, "Technology in Schools: Hearing from the Teachers," October 1993, 94 p., NTIS No. 95-170973.

Beverly Hunter and Bruce Goldberg, Bolt Beranek and Newman, Inc., "Learning and Teaching in 2004: The Big Dig," December 1994, 41 p., NTIS No. 95-171005.

Nancy Kober, "Teachers and Technology: The Federal Role," May 1994, 136 p., NTIS No. 95-170965

John R. Mergendoller et al., Beryl Buck Institute for Education, "Exemplary Approaches to Training Teachers to Use Technology, Vol. 1," September 1994, 210 p., NTIS No. 95-170932.

John R. Mergendoller et al., Beryl Buck Institute for Education, “Exemplary Approaches to Training Teachers to Use Technology, Vol. 2, Appendices,” September 1994, 135 p., NTIS No. 95-170940.

Margaret Riel, Interlearn, “The Future of Teaching,” January 1994, 31 p., NTIS No. 95-172219.

Center for Technology in Learning, SRI International, “Year 2005: Using Technology to Build Communities of Understanding,” November 1994, 42 p., NTIS No. 95-172235.

TERC, Cambridge, MA, “Review of Research on Teachers and Telecommunications,” May 1994, 70 p., NTIS No. 95-170957.

Jerry Willis et al., University of Houston, “Information Technology in Teacher Education: Surveys of the Current Status,” March 1994, 300 p., NTIS No. 95-170999.

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