Chapter 5

The Teacher's Role

Photo credit: Blue Earth Elementary School, Blue Earth, Minnesota

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The Teacher's Role

"While our system of schools contains many consequential characteristics . . . none is more important than who the teachers are and how they work. Without good teachers, sensibly deployed, schooling is barely worth the effort. "

Theodore Sizer[1]

INTRODUCTION

Educators and educational researchers consistently cite one factor as central to the full development of technology's use in the schools—the classroom teacher. Computers, though powerful, are not self-implementing. But in the hands of a creative and technically competent teacher armed with appropriate software, the computers and allied technologies can provide a new world of teaching opportunities. They are the newest, most versatile tools of the teaching trade.

This chapter, while dealing with the teacher's role in the effective use of technology in schools, focuses on the use of computers for several reasons. As stated elsewhere in this report, many of the emerging interactive technologies are computer based. And, although technologies such as distance learning and interactive videodisc are becoming increasingly important in K-12 schools, they are currently used less than the computer. While instructional television through the videocassette recorder (VCR) is experiencing a renaissance in the schools, it also often serves as the ". . . spark plug for educational chain reactions incorporating computer applications such as word processing or computer simulations."[2] Finally, all interactive technologies raise similar issues: how do teachers use them and why, how does their use affect the teacher's role, what training do teachers need to take advantage of them, and what barriers stand in the way of fuller utilization?

[1] Theodore Sizer, *Horace's Compromise: The Dilemma of the American High School (Boston,* MA:Houghton Mifflin Co., *1984).*

[2] See Milton Chen et al., *Case Studies of Exemplary Instructional Television Use* (San Francisco, CA: KQED Instructional Television, January 1988).

FINDINGS

- **Despite the presence of computers in almost all K-12 schools nationwide, only half of the Nation's teachers report that they have used computers in instruction. Barriers to use are both practical (inadequate access to the technology) and intellectual (initial fears of using the technology and a lack of understanding of the computer's value in serving** the curriculum).
- **Few teachers have found ways to exploit the enormous potential which interactive technologies offer. Use in most cases is adapted to the curriculum at hand and the teacher's existing teaching methods. Teachers are just beginning to understand the computer's potential for helping** students solve problems, think for themselves, and collaborate with other students. The computer can help shift the teacher's role from education dispenser to coach, guiding and encouraging each student to become an active participant in his or her own learning.
- Most teachers want to use technology. Some of their reasons are personal: the desire to develop professionally, to learn the newest tool of the trade, and to do their jobs better. Some are centered on benefits they see for their students: preparation for the world of technology outside school and a vehicle to channel the students' enthusiasm for technology into creative learning. Other rea-

sons include fear of being left behind or being replaced by the technology, and pressure from parents, school boards, and administrators.

- The process by which teachers appropriate technology is more complex than that by which teachers adopt other changes. Initial fears regarding technology may need to be overcome before teachers feel in control. Training with computers is an ongoing process that takes place at varying levels, depending upon the teacher's responsibilities and the way the technology is to be used. Teachers need opportunities for practice with the computer, with continuing support from trainers or computer-using peers. Once teachers feel comfortable with the computer as a tool to help them do their job, they look for ways to integrate it into their existing curriculum and seek opportunities to do things previously impossible in the classroom. Few then wish to go back to teaching without computers.
- Teachers use computers in ways that work best with their own teaching styles and methods, but these styles evolve as teachers gain more computer experience. Some teachers individualize instruction, encourage individual and group problem solving, and enhance peer learning when they have computers in the classroom. Activities facilitated by computer use include teaching writing, doing laboratory experiments in science, solving sophisticated problems in mathematics, or using simulations in social studies classes.
- The very opportunities opened by the computer can create more work for the teacher, making the job harder initially. Although the computer can minimize some administrative chores and ease classroom discipline, other tasks which accompany computer use (individualizing lessons, matching software to the curriculum, scheduling student computer time, monitoring use, providing assistance, and troubleshooting) add a net burden to the teacher's time in the short term.
- The teacher reform movement has created special challenges and opportunities for the application of technology to education. As more teacher education programs become 5-year programs, with students earning undergraduate degrees outside of education, computer training will need to be sandwiched into a tighter teacher preparation curriculum. Integrating the use of technology in subject matter courses can be an effective way of making computer skills part of preparation of new teachers. Having student teachers intern with computer-using classroom teachers can also provide role models for technology use.
- Preservice technology training, while important in giving prospective teachers facility with the computer, only serves as an introduction. Teachers need continuing training as the technology changes, as new and more effective applications are developed, and as more is learned about learning with technology.
- The Federal Government's role in training teachers to use technology has been a limited one, although Federal support was important in creating a "first wave" of computer-using educaters. The major players in supporting teacher training have been the States and local districts. They have made substantial financial commitments to preparing teachers to use computers, but this support has been highly variable across States and districts.
- Any further investment in technology for education must factor in teacher training and support, whether that effort is focused on a few specialized teachers or on all teachers. Although most of the responsibility for training will fall on local school districts, there are important ways to use the resources of intermediate education agencies, States, the Federal Government, and the private sector.
- School administrators must support and encourage teachers to use technology throughout the curriculum. For this to occur, they too will need training that provides them with an understanding of instructional applications of computers and a vision of the potential for change they offer.
- **Efforts to support teachers require attention to more than immediate needs and current practice. The technology offers new possibilities for enhancing the teaching environment and teachers' personal and intellectual growth. Teachers need an environment in which they can feel free to experiment if they are to discover the opportunities that the technology can provide.**

HOW TEACHERS USE TECHNOLOGY

Background: Teacher Attitudes

Almost all teachers want to use technology.[4] Some of the reasons cited are related to personal growth, some to concern for students, and some are reflective of external pressures. Being professionals, most teachers want to stay abreast of the latest developments in their field. As one teacher stated: "I always made the commitment that when I became a teacher who didn't want to do the new things or at least investigate them and give it a good shot, then 1 didn't want to teach any--more.'" Some see the use of computers in all aspects of society as inevitable. They want to be able to prepare their students for the outside world. Many have used computers at home and are intrigued by the possibilities they offer, or they have observed their students' enthusiasm for computers and want to channel that enthusiasm to the classroom.

Some have seen the computer's potential as a tool to do things in the classroom they had been unable to do before. "In some ways I'm rewriting the curriculum. I can't show on a blackboard a thousand balls dropping through a triangular grid. And to get a distribution, I want a graph to talk about theoretical and experimental probability. So I use computers a lot for simulations. " They understand from experience that students learn in different ways. "Having computers in the classroomcan help provide different kinds of learning experiences for students; for example, the visual learner, or those overwhelmed by the large classroom and all its distractions, who really pay attention to the focus of the computer screen. "

For many teachers, the computer lights a fire under their teaching spirit, rekindling waning enthusiasm for teaching. As one teacher said, describing her colleague, "The use of computers in teaching gave him a new lease on life. This is all he talks about—what his students did in class. He's really excited about it!"

Finally, some teachers admit that they are responding to outside pressures. Administrators and parents want teachers to use the machines that have been placed in their classrooms. Having computer skills can also open doors to new jobs in the schools, as in cases where teachers avoid staff cutbacks by switching to positions that involve computers. Pressure from teacher peers can also be a strong motivator. When asked to describe the relationship between teachers who use computers in their classes and those who do not, one teacher stated, "It's the advocates versus the guilty!"

Yet, not all teachers embrace computers with open arms. As one teacher said: "They rolled this thing (the computer) into my class and said, 'Here, it's yours for the month. ' What did I want with it? It was a distraction. I let each kid have a half hour on it and the other 23 would be looking at the clock the whole time, saying 'Is it my turn yet?' By the end of the first week I just used it as a place to throw the kids' coats on. " Others express their concern in more positive terms: "I don't plan to use it and don't feel the need to apologize. I teach the way I teach because it works for me and my students. I'd rather take a course in the summer on Greek tragedy so I can add that to my literature course, than a course in how computers work. It's a question of allocating a valuable resource, my time, where, in my professional judgment, I can best nourish my own growth and that of my students. "

Finally some teachers fear that their students may lose important underlying skills, such as penmanship or computation, when adopting new technologies that replace these skills. Fearing the loss of the old in adopting the new is not a novel concern. In the words of an early critic of technology: "Those who acquire it will cease to exercise their memory and become forgetful; they will rely on (it) to bring things to their remembrance by external signs instead of on their own internal resources. " He went on to criticize this new technology for replacing a human response with a manufactured artifact and

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[3]This section draws heavily on Martha Stone Wiske, Harvard University, Educational Technology Center, and Phillip Zodhiates, Education Development Center, Inc., "How Technology Affects Teaching," OTA contractor report, October 1987.

[4]As early as 1982, a National Education Association random sample of approximately 1,200 teachers revealed that 83 percent of the teachers surveyed wanted to take a course to learn how to use a computer for Instructional purposes. Seventy percent or more believed that computer use in schools has a positive effect on student motivation, subject Interest, attention span, self confidence, and cognitive learning. National Education Association, *Teacher Survey NEA Report: Computers in the Classroom* (Washington, DC: 1983).

[5]The comments in quotes are derived from teacher interviews conducted for OTA by Wiske and Zodhiates, op. cit., footnote 3.

for cheapening learning by democratizing access to knowledge. The critic was Plato, in *Phaedrus,* arguing against the introduction of writing in ancient Greece.[6]

Some of the objections voiced by teachers are based on prior skepticism, partial information, bad training, and lack of exposure to uses of computers. Teachers (and others) also tend to blame computers for problems caused by the people who use them poorly. Without contact with effective computer-using teachers they have no positive models. (See box 5-A.[7])

[6]As cited in James Cummins and Dennis Sayers, *MicroTrends: Computer Writing Networks and Empowerment* (Reading, MA: Addison-Wesley, in press).

[7]The portrait in this box and in boxes 5-B and 5-C are composite profiles of fictionalized teachers who illustrate common themes of teachers' varying approaches to technology use in the classroom. The

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Box 5-A.—Deciding Not To Use Computers[1]

"Charles Perry" is the chairperson of the English Department at an affluent suburban high school of 1,100 students. A teacher for 21 years, Charles has an M.A. in English. By all accounts, Charles is a masterful teacher who knows exactly what he wants to accomplish in the classroom.

Charles took a 1-day inservice computer course 10 years ago: "[I] got nothing out of it. They went so fast; I was lost. The manual was unreadable," he recalls. Since then he has observed colleagues going through similar training experiences, which he blames on computer enthusiasts who ". . . go flying off without you and make you feel stupid."

Charles offers no apologies for his decision not to use computers in his teaching even though computers are available in his school. "Sure, with time and better instruction I could learn how to use them, but the computer just isn't important to me," he says. "I'd rather spend my summers writing than taking computer classes." Describing himself as a ". . . 19th century person kicking and screaming my way into the 20th century," he is profoundly skeptical of the usefulness of computers. "What's it for?" he asks in an exasperated tone. "I don't see that thinking—the kind of thinking you'd want for citizenship—is enhanced by these machines." Unlike many teachers of writing, Charles finds that the word processors discourage rather than facilitate revising and editing. "My kids do all their papers on word processors at home and they don't seem to be as long or rich as they were when done in longhand and then typed." He thinks the problem is that many students are satisfied with turning in their first drafts: "They think that because it looks neat, it's done." Charles believes that until teachers as a group demand more rewriting they are not going to see much improvement. And he worries that many teachers are also seduced by the neatness of computer-produced papers.

Like many good teachers, Charles cherishes the "on-stage" performing aspect of his job. He sees computers as a source of competition for the students' attention and suggests that technology may have the greatest appeal for teachers who are less successful at holding the attention of their students and therefore want to try a different pedagogical approach.

In addition, Charles associates computer use with a style of teaching he mistrusts. He points to a coworker, "a very casual kind of person," who now spends less time on traditional instruction while students play around on the computer. He is also dismayed by his impression of the computer laboratory next to his classroom, describing it as a chaotic place where children receive little supervision. He fears that technology is tempting teachers to relinquish their instructional role and become ". . . just facilitators of student computer use."

Finally, Charles fears that computers will disrupt the traditional student-teacher relationship. He has heard horror stories of colleagues using drill and practice software in which ". . . a kid can just push a button and the teacher has no way of knowing whether he has the wrong answer or not, unless he happens to be standing right behind him. There is nothing that feeds back to the teacher how each kid is doing." Having had no contact with teachers who find that the computer provides them with a valuable window on their student's thinking and learning, Charles is convinced that technology comes between teachers and students.

[1]Composite portrait prepared by Martha Stone Wiske, Harvard University, Education Technology Center, and Phillip Zodhiates, Education Development Center, Inc., "How Technology Affects Teaching," OTA contractor report, October 1987.

Uses in the Classroom

> There is not "one computer in education"; there are many possible educational computer cultures.[5]
> Sherry Turkle

There are as many ways teachers can use computers in the classroom as there are varying teaching styles. Teachers use groups of computers in laboratories very differently than one or two in the classroom. A single computer in a classroom can be used by the teacher in various ways at various times—sometimes as a provocative learning station for individual students, sometimes for interactive demonstrations led by the teacher for the whole class, and in other instances for collaborative problem solving by a small group of students. Use in social studies is different from that for science laboratory work; drill and practice for review of basic skills is very different from students programming a computer to make machines move. Indeed, asking, "In what ways do teachers use computers, and how does the computer affect the teacher and his or her teaching?" seems as broad a question as, "How do teachers teach with books and what effects do books have on teachers?" (See box 5-B.)

One of the most frequently cited areas where computers make possible things that could not be done before is in special education. The computer has been described by some as "the freedom machine," opening the door to educational pathways previously inaccessible to handicapped or learning disabled students. For the physically handicapped, adaptive devices can make communication itself possible. For trained teachers with access to appropriate information, computers can be powerful teaching tools for special education students. (See box 5-C.) However, many special education teachers (and classroom teachers who have disabled students mainstreamed in the regular classroom) are not aware of what is available and what is possible, In addition, the educational system provides few if any incentives or rewards to teachers who go out of their way to see that their special education students have equal access to computers. As a result, the special education student, especially if mainstreamed into a regular classroom, often is placed, like the non-English speaking student," at the end of a long line when it comes to classroom computer use.

How the Use of Computers Can Change Teaching Style

One of the most significant impacts of the use of computers in the classroom is change in teaching style. Teachers can go beyond the traditional information delivery mode where they are presenters of ready-made knowledge and become facilitators of students' learning. With computers, students can work on problems individually or in small groups while the teacher acts more like a coach circulating among them and giving assistance. (See box 5-D.) Some teachers find that they are able to observe more of the learning process when watching students interact with computer-based materials. Some teachers welcome the opportunity to learn alongside their students: "I've become more of an involved participant than an authority figure . . . a learner with students rather than a presenter of facts." For many, this is a significant change from how they were taught to teach. It can be both exhilarating and intimidating.

Teachers who use the computer as a medium that students can manipulate individually or in small groups find their students become more actively engaged in learning and thinking than during traditional lecture-oriented lessons. Such teachers use the computers to give students more responsibility for their own learning.[10] Students can work at their

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composites are drawn from Wiske and Zodhiates, op. cit., footnote 3. In this report a sample of 76 teachers, from 10 regionally diverse school districts, including urban, suburban, and rural sites, were surveyed in extensive telephone interviews. Twenty classroom teachers from various school systems in the Boston area were also interviewed. In the interviews, which lasted on average 1 hour, open-ended questions were asked concerning their personal classroom computer use, the computer training and support they had received, and their assessment of the impacts of the computer on their teaching style and on their students. In selecting the sample, the researchers attempted to balance for teacher position, gender, and extent and type of computer use. The composites are intended to draw a picture of, if not real people, real types of teachers, to give a feel for common categories and concerns. The device results in a cross between straight statistical survey research and hypothesis. See the Wiske and Zodhiates report for additional composite profiles.

[5]Sherry Turkle, personal communication, November 1987.

[9]See U.S. Congress, Office of Technology Assessment, "Trends and Status of Computers in Schools: Use in Chapter 1 Programs and Use With Limited English Proficient Students," staff paper, March 1987.

[10]See *Sizer,* op. cit., footnote 1, for a fuller discussion of the traditional American high school and the docility it engenders in students. In his report he states, "No more important finding has emerged from the inquiries of our study than that the American high school student, as *student*, is all too often docile, compliant, and without initiative." Sizer contrasts this to what he calls ". . . the hungry student . . . actively engaged in his or her own learning. The student takes the initiative and works at teaching himself" (p. 54).

Box 5-B.—Using Computers in an Elementary Classroom[1]

"Laurie Adler" teaches first grade in a typical elementary school where she is responsible for teaching 26 students everything except art, music, and gym. She has taught for 14 years and has a bachelor's degree in elementary education. Four years ago she was unexpectedly given a computer to use in her classroom. Although computer use was not a required part of the first-grade curriculum, she believed she was expected to use the one she was given. "It was just dive in and get wet." She took one course offered by her district, but has basically taught herself by experimenting with games, educational software packages, and word processing. She continually reassured herself: "Not to worry, there's plenty of time to learn how to do this. These are little kids, I just have to keep a day ahead of them." Over the past few years, she has gradually felt more at ease using computers, discovering that "you can tell the computer what to do, that's basically what all the software is about. What a wonderful revelation—that it's not some magical machine!"

Laurie has had one computer in her classroom at all times and also has had access to several "floating" computers on carts. Her instructional approach with computers is flexible. The computer serves as a "learning station" in her classroom. "I've found that it just fits in with the way I like to do things during school. . . . Having a computer in the classroom helps me to keep more of an individualized approach to teaching." Laurie also uses the computer for whole class lessons and small group work. Her students use some mathematics and reading software, but they use the computer mostly for writing. The children have written short stories and poems far superior, she believes, to what they would have produced with paper and pencil. Because her students are always enthusiastic about using the computer and find that writing can be fun, she believes that the computer has had a positive impact. She observes longer attention spans and more patient behavior in her students. Moreover, by working together on the computer, her students are beginning to appreciate each other's strengths.

Initially, Laurie found that having a computer in the classroom presented logistical problems. "There were a lot of interruptions in the rest of the class when these kids were working on the computer. Then I found it works to have a master computer pal on a rotating basis, a child who really knows a piece of software, to whom those using the computer can go for questions rather than coming to me." She believes that computers encourage a sense of community in her class. Students often choose to work together on the computer; sometimes two children even share a chair.

Laurie thinks teaching with a computer is a little more difficult—the computer makes her work harder. "I have to keep things very focused in terms of the kinds of projects we're working on to be sure that all kids have an opportunity to use the computer." Each week, she makes up a schedule to ensure that everyone will have a chance to work on the computer once or twice a week for about 30 minutes. Laurie would use computers even more extensively if only she had more—more computers, more time, and more training. For now, she arrives at school early to prepare materials, and sometimes works late into the afternoon as well. Although no monetary rewards or special status are associated with knowing about or using computers in her school, Laurie says: "You know where the reward comes: it comes when children choose to stay after school, to come in at 8:00 o'clock in the morning to work on the computer, and when parents says that they appreciate the extra effort that you've made. I really appreciate that."

[1]Composite portrait prepared by Martha Stone Wiske, Harvard University, Education Technology Center, and Phillip Zodhiates, Education Development Center, Inc., "How Technology Affects Teaching," OTA contractor report, October 1987.

own speed and can figure out more for themselves. Some students who do not respond well to lessons based around a lecture format deal more positively with the interactive, visual medium of the computer.

The typical school today has a specialized computer laboratory and/or a few classrooms with one or two computers each.[11] As demands for separate computer literacy and programming courses diminish, some schools are moving their stand-alone com-

[11]See ch 8, Box 8. A_ Apple Classroom of Tomorrow, for a description of the exceptional case of classrooms where every student has a computer on his or her desk.

Box 5-C.--Using Computers With Special Education Students'

"Chris Johnson" teaches special education: learning disabled, *mentally retarded,* physically handicapped, and speech impaired students ranging in age from 12 to 18 years in a large urban high school. Several years ago Chris enrolled in a graduate level course on educational uses of the computer. He saw the possibilities of using computers for individualized instruction and enhanced social interaction with his students, but realized that available software would need to be adapted or new software "invented" to meet his students' special needs. It was embarrassing for his students to use elementary school software when they were in high school. He wrote a mini-grant proposal to a hardware manufacturer to adapt promising special educational materials, making them user-friendly and suitable to the structure and pacing of a special education classroom. As a result, he was awarded two computers for his class.

Chris explored various ways to apply the computer to his teaching. He has used the program Printshop as a business venture to help students develop vocational and social skills. Word processing skills have been particularly important for improving student self-esteem when, perhaps for the first time, a disabled student produces something legible that could be put in a book and shown to parents or friends with great personal pride.

Like many computer-using teachers, Chris views the computer as a tool that can do many things. Perhaps the most telling reason for Chris' enthusiasm is the computer's role as "equalizer" among his students and between them and other students in the school. He has instituted a peer buddy system to promote this process, pairing a special education student with a mainstreamed student to work together on computer activities. "My retarded kids could whup those regular kids with some of the memory games and some little spelling games and things like that. I think it was one of the first times that the regular kids perceived this normal competency level in handicapped kids." He has observed how the computer allows students with disabilities to find common ground with other students in the school. He also believes that many of his handicapped students will later in life need to interact with machines on the job or at home. School experiences with computer-based technology can present the handicapped learner with opportunities for future success.

Chris claims that the presence of computers in his classroom has made a substantial difference in the way he teaches. Some software has led him into content areas he would not otherwise have explored. The adaptation and invention of other software programs for special students has forced him to concentrate on students' control over their environment and over their own learning. He has observed his students using the computer to open new channels of communication with their peers, especially those students who have had difficulty with the social dynamics of the classroom, in making friends, or working with others. "I've had romances form around the computer;" for some of the students it was a deflection of having to work that difficult interaction of male/female roles. His enthusiasm is tinged with the understanding that computers are costly and require alot of his time to organize their use in the classroom, but he is undaunted. "The most compelling reason for using computers with special education students is that they work. They function as a multipurpose coping mechanism and as a catalyst to better social interactions, particularly important features of academic success in the special education classroom."

[1]Composite portrait prepared by Martha Stone Wiske, Harvard University, Education Technology Center, and Phillip Zodhiates, Education Development Center, Inc., "How Technology Affects Teaching," OTA contractor report, October 1987.

puters into individual classrooms. Many teachers have found that having only **one or a few** computers in the classroom requires students to work together. This stimulates cooperative learning and peer teaching among students, and develops their communication and social skills. Even simple drill and practice programs may be used with-pairs or triads of students at one terminal taking turns and helping each other.

For example, OTA staff observed a junior high English for Speakers of Other Languages classroom, where three boys, one from Honduras, one from Laos, and another from Pakistan, worked together at the computer puzzling over a multiplication/division drill software program written in English. The boys' skills in spoken and written English were limited and varied, but together they encouraged each other to solve the mathematical problems so

Box 5-D.—The Teacher as a Coach: Teaching Science With a Microcomputer-Based Laboratory[1]

Douglas Kirkpatrick teaches an eighth grade physical science class in Walnut Creek, California. Working with a research team from the nearby Lawrence Hall of Science, he has been using the computer as a "silent laboratory partner," helping his students understand concepts in heat and light in a new way. His 32 students are teamed up in pairs using 16 microcomputers donated by Apple. The software is made up of microcomputer-based laboratory (MBL) materials, temperature probes, light probes, and heat pulsars for the collection of data, with accompanying curriculum materials, all developed by the Technical Education Research Centers in Boston.

Kirkpatrick found that his students had reasonable intuitions about the effect of insulation on the temperature of a liquid— gained from their prior experience with styrofoam cups—and the relationship between volume of a liquid and the amount of heat that needs to be added to make it boil—gained from heating large and small quantities of liquid in the kitchen. However, Kirkpatrick's students, like other science students, had persistent misconceptions about other scientific phenomena. As he noted, many students believed "you only have a temperature if you are sick," or "you have more hot chocolate, so yours is hotter than mine," or "temperature is all the degrees, but heat only refers to temperatures that are above warm." Merely telling students how heat differs from temperature or having them read about it in a textbook has traditionally had little or no effect on these entrenched misconceptions.

In the past, Kirkpatrick had clustered his students in small groups in a laboratory to study temperature. He had them observe water and moth flakes cooling, with some students calling out times and temperatures while others painstakingly recorded the data. Later, teams constructed graphs of their efforts and attempted to relate the curves on the graphs to key moments in the experiments. While students typically found these laboratory experiments more interesting and fun than a lecture or reading about temperature, the underlying cognitive concepts still did not seem to take hold.

Doing the experiment with the MBLs, Kirkpatrick's students were freed from the tedious mechanics of data collection, enabling them to focus on changes occurring before their eyes as recorded on the computer. Having the computer simplified experiments that would otherwise have been confusing. Real-time computer graphing was an antidote to their typically limited adolescent attention spans. His young experimenters, like "real" scientists, were able to use technological tools to collect, display, and analyze data, freeing them to concentrate on the effect of the experimental action, to observe, discuss, and analyze. Students were able to repeat their experiments easily when they had questions. They could also readily compare results with their fellow students, giving rise to lively class discussions about the meaning of the experiments.

If the computer was the silent laboratory partner, what was the teacher's role? Like any laboratory situation, where students have a hands-on engagement with learning, the teacher became a coach. In this instance, Kirkpatrick found that most students at first completely trusted the data from the computer. It was Kirkpatrick's job to direct their attention, to help them become aware of sources of invalid data, to teach them to diagnose the causes and help them evaluate data the computer collected. He taught them to detect poorly calibrated probes, discard data from such probes, and to recalibrate their scientific instruments. He guided their discussion to confirm their understandings.

Kirkpatrick has been delighted by the interactions he has observed among the students, and presides over countless fascinating classroom discussions of complex science concepts. He says, "I can't imagine a physical science laboratory without computers anymore."

[1]This is a nonfiction account of the activities carried out by a real classroom teacher. See also Marcia C. Linn, University of California at Berkeley, "Using the Computer as a Laboratory Partner: Cognitive Consequences," paper prepared for the symposium on "Computers in School: Cognitive and Social Processes" at the Second EARLI Conference, Tubingen, Germany, September 1987.

Photo *credit: Computer Learning Month*

"1 learn a lot more about my students because I can watch them learn. Before, I couldn't watch them learn, because I was busy delivering the curriculum. My role has changed with computers. "

—OTA teacher interview.

they could "win" the game. Three boys, three languages, one computer. Together they succeeded where one alone would have been lost. The teacher, busy elsewhere in the classroom, was available to them but was called upon for assistance only when all three were stuck on a point. Besides learning the mathematical facts at hand, the students were learning other social and communication skills equally important for school success.

Cooperative learning at the computer works particularly well in classroom activities using simulations and problem solving software. Students can be grouped with mixed abilities and work together on tasks that cannot be completed individually. Many software simulations are designed with the assumption that only one or a few computers are available for a whole class. Such simulations also provide opportunities for teachers to integrate various disciplines. For example, teachers using the popular simulation *The Oregon Trail,* which puts students into the role of early pioneers, have incorporated subject areas beyond social studies: language arts (having students keep journals); mathematics (in planning purchases for the trip); art (making maps and drawings for the walls illustrating the journey); science (learning about climate, wildlife, and nutrition during the trip), and music (singing songs of the pioneer days).[12]

Group learning with the computer engages students as actors and decisionmakers and channels their need to feel important as contributing members of a team. Too often this need is met only by after-school activities, such as band, play production, or putting together the school newspaper. [13]

This cooperative, group learning model has of course been used in other situations without computers as the focal point, but the interactivity of computer simulations and the machine's management of content frees the teacher to observe the groups in action, and to concentrate on the art of leading the students in their analysis and discussions.

Not all teachers welcome this change in the teacher's role. For some, it can be threatening. "If all the eyes in the classroom aren't on me, I'm not teaching." Others wonder, "Are the teachers who are not successful with traditional teaching methods the ones who switch over to using the computer?"

Other computer-using teachers report that computers have exerted little or no influence on their personal classroom behavior. These reactions reflect

[12] Holly Jobe, Montgomery County Intermediate Unit 23, Erdenhelm, PA, "A Look at Cooperative Learning in the Computer Classroom," *interface: Montgomery County Microcomputer News*, vol. 4, *No. 3,* November 1987, p. 2.

[13] 'Research has documented the powerful value of peer learning. Researchers studying the introduction of LOGO in classrooms have seen a "restructuring of expertise" which included peer expertise recognized by students. See Jan Hawkins and Karen Sheingold, "The Beginning of a Story: Computers and the Organization of Learning in Classrooms," *Microcomputers and Education: 85th Yearbook of the National Society for the Study of Education* (Chicago, IL: University of Chicago Press, 1986), pp. 40-58.

Photo credit: Center for Children and Technology, Bank Street College of Education

Peer learning and language development can take place as students work together at the computer.

different circumstances and styles of computer use. Since drill and practice or tutorial software is designed for use by individual students working independently from the teacher, it is understandable that teachers using such software find computers have little impact on their teaching style. They see the computer as a way of giving their students more "seatwork" or practice time, which they would otherwise provide with mimeograph practice sheets or other kinds of drillwork. Furthermore, presenting concepts to a whole class, then breaking the class into small groups to allow the children to become actively involved in solving problems, can be done with or without the computer. For teachers who have long used such methods, computers seem a natural extension of their arsenal of teaching tools. Finally, for many teachers, especially those in elementary schools who have classroom activity centers, the computer provides another engaging learning station.

Effects on Classroom Management

Almost all teachers who have taught with computers agree that, at least initially, most uses of computers make teaching more difficult. It takes planning to handle the basic logistics of scheduling[14] which students will use computers when and where, to make the necessary equipment and materials available, and to have a fall-back lesson in case the computer malfunctions. It also takes a great deal of planning to incorporate computers into a lesson. Much of today's computer software covers only one or a few instructional concepts. The teacher must

[14] In many schools, just getting access to the limited computers or laboratory time can be a major scheduling nightmare. This is another area where administrative support is important. Principals need to be aware of the scheduling issues (and equity implications) in determining who gets access to the equipment.

Photo credit Massachusetts Institute of Technology

"Computers give teachers a better opportunity to individualize, but that doesn't mean it's easy. Individualization is difficult to manage."

—OTA teacher interview.

find the best ways to incorporate sundry pieces into the overall curriculum. As one teacher said:

> It took me a while to get used to all this. It took me two months to understand what was going on . . . then a year to get good at it . , . to learn all the software programs and all the intimate details and intricacies of how the room worked. It took me a good year to be comfortable . . . but by the end of that time my room was pretty red-hot.

Although teaching with computers may require more preparation initially, teachers also report that technology eventually eases some aspects of classroom management. When students find their work on the computer engrossing, discipline problems decline. Absenteeism can be cut down, both by increased student enthusiasm for school, and through management systems such as automatic telephone calling systems that report to parents on unexcused absences in school.[15] Spreadsheets or special purpose grading programs, word processors, database managers, and desktop publishing can streamline many of the teachers' administrative burdens such as maintaining records and preparing materials.

Management tasks can be greatly simplified when teachers use networked systems. Some of today's integrated learning systems, which use large capacity storage systems on hard disc or compact disc-read only memory (CD-ROM), can hold thousands of individual lessons matched to the schools' curriculum, at levels ranging from primary through sixth grade skills, for the teaching of reading, language arts, and mathematics. Each student in the classroom can be working on a different lesson, with the management system automatically recording each student's progress, printing out for the teacher a detailed record of the student's work. The printout indicates which problems the student answered correctly, which were missed, and how long it took the student to complete the tasks. The teacher can then incorporate this information in planning which concepts must be reviewed when students return to the classroom, and cluster students by needs. By greatly easing recordkeeping and monitoring, these systems make it possible for the teacher to individualize teaching to a much larger degree.

Effects on Teacher Accountability: The Testing Question

One of the major issues in teaching is testing and teacher accountability, an issue that also has a di-

[15] "A recent study at the University of Tennessee examined alternatives for dealing with student absenteeism at nine comprehensive high schools, matched for their student body characteristics. Over a 60-day period, it was found that student absenteeism dropped 55 percent in schools where the parents of absent students were called by computer-based automatic calling systems in the evening, while student absenteeism dropped only 18 percent when parents of students missing school were called by school personnel during the school day. The computer-generated calling systems were found to be a much less expensive means of contacting parents. Maurice M. McDonald, University of Tennessee, "A Comparison of the Effect of Using Computer Calls and Personal Calls for Improving Pupil Attendance in Public High School s," doctoral dissertation, 1986.

rect bearing on use of computers and other technology in the classroom. Teachers' evaluations are often tied to students' scores on standardized tests that do not directly measure the progress of students who are tackling open-ended problems, collaborating with other students, and turning in assignments that require more than a right/wrong answer. [16] Teachers thus have an incentive to use skill-specific software that matches the curriculum goals for which they are responsible. They are deterred from exploring exciting possibilities offered by software that is not tied to a particular measurable skill, but which may provide opportunities for the student to engage in problem solving or to just "play around."

Educators have legitimate concerns regarding how the work done on the computer fits into the curriculum. They know that the bottom line is testing, and that they are held accountable for assuring that the facts of the subject matter are covered in their classroom. Therefore, although a teacher may recognize the value of seeing the students working together, cooperating, and developing creative solutions to problems offered by simulation of an historical event, this same teacher must worry about whether these students have memorized the historical facts that tests measure.

[16] Hawkins and Sheingold, op. cit., footnote 13.

TEACHER TRAINING IN TECHNOLOGY[17]

Although the State, district, and administrators set systemwide curriculum requirements, it is the teacher who determines how instructional activities are carried out. The classroom teacher looks at the time and texts at hand, slices the subject matter into daily lesson plans, and determines how to teach the required materials. If computer technology is to have an impact on teaching and learning, teachers must be comfortable with computers, seeing them as tools that enhance rather than interfere with their daily teaching. For this to happen, teachers need special training.

However, the vast majority of today's teachers have had little or no training on how to apply computers in teaching. Recent reports suggest that only about one-third of all K-12 teachers have had even 10 hours of computer training. '8 Much of that training has focused on general computer literacy, at the "introduction to computers" level, rather than on the more sophisticated and comprehensive issues of how to integrate computer technology into the curriculum or how to use the computer for a variety of teaching tasks, some of which may be entirely new. Teachers need more technology training (learning how to use computers to accomplish their current classroom goals), as well as more technology education (gaining enough knowledge about the computer and understanding of its capabilities so they can explore the potential of the computer to improve learning in nontraditional ways). OTA finds that teachers need both training and education if technology is to take hold in schools. They need to know how to work the technology to meet their goals, and how to work with it in changing goals based on what the technology makes possible.

Training and professional development, for both new and veteran classroom teachers, need to be seen as continuing efforts. Inservice education can bring the existing cadre of teachers up to speed, help them overcome computer anxieties, and guide them as they attempt to adopt powerful, multipurpose, and ever-changing technologies in the classrooms. Concurrently, it will be necessary to ensure that those entering the profession have the most up-to-date technology skills and underlying understandings. Unfortunately, the solution, like so many other answers to educational questions, is neither simple nor easily attainable.

Teacher Education Reform Efforts

The need to improve teachers' technology training and education arises at a time when reforming teacher education is receiving much attention. This comes on the heels of several years of critical review of U.S. public education. Two major reports address these reform issues and their implications for teacher

[17] Much of the work in this section is based on Allen D. Glenn and Carol A. Carrier, "A Review of the Status of Technology Training for Teachers," OTA contractor report, Sept. 22, 1987.

[18] Office of Technology Assessment, op. cit., footnote 9.

education.]' The Holmes Group, composed of deans from large, research-oriented colleges, and the Carnegie Forum, a group of political, business, and educational leaders, each call for major changes in the preparation of teachers, higher standards for teachers, and increased professionalism, along with appropriate professional compensation.

The Holmes Group recommends that colleges abolish the undergraduate education major and move teacher education to a post-baccalaureate degree program. This would be a drastic change for almost all schools of education because, while post-baccalaureate programs have existed for years, they are the exception rather than the norm.

The Carnegie Forum has set into motion a National Board for Professional Teaching Standards that will develop national examinations and guidelines for teacher certification, efforts many feel will change the profession profoundly. Concomitant efforts to reform teacher education are also occurring at the State level. More than 25 States require teacher competency testing in at least the basic skills of reading, writing, and mathematics. State regulations also specify the number of credits permitted in teacher education programs. Debate continues over how much time should be spent on content versus process in teacher education.

As a result of these calls for reform at the State and national levels, teacher education programs are changing. In the midst of these sweeping changes, technology training is not the only issue in the teacher preparation debate, but it can be one piece of the solution. The teacher reform movement provides the opportunity to consider new roles for teachers and how technology fits in.

[19]The Holmes Group, Inc., *Tomorrow's Teachers: A Report of The Holmes Group* (East Lansing, MI: 1986); and Carnegie Forum on Education and the Economy, *A Nation Prepared: Teachers for the 21st Century*, the Report of the Task Force on Teaching as a Profession (New York, NY: May 1986).

PRESERVICE TECHNOLOGY EDUCATION

A Brief History

As the number of computers increased in elementary and secondary schools over the last 10 years, schools and colleges of education tried to respond. Many incorporated a basic computer literacy course into their curriculum, covering such topics as: "What is a computer? How does it work? How do you program it?" Proponents of programming suggested that learning to program would remove much of the mystery surrounding the operation of computers and would give teachers greater flexibility in using them.[20] Teachers would also be able to develop their own software in a period when good educational software was scarce. [21] Others found emphasis on programming reinforced the idea that only technical people—like those in the audio-visual/instructional design departments where early computer courses often originated, or those in mathematics or the sciences—could understand computers. Other teachers were often intimidated by and/or uninterested in computers,

Current Efforts To Prepare Today's New Teachers To Use Computers

Approximately 142,000 new teachers were expected to graduate in 1987-88.[22] Over 1,500 private and public institutions prepare these teachers. Their programs range in size from those with a handful of teachers to those that graduate several hundred each year. Today almost all of these teacher licensure programs provide some instruction in the use of computers. [23]

Despite course offerings, graduates of teacher preparation institutions apparently do not feel

[20]William Bramble et al., *Computers in Schools* (New York, NY: McGraw Hill, 1985), p. 225.

[21]T.J. Singletary, "Programming for Leadership," *Journal of Teacher Education*, vol. 38, No. 4, 1986, pp. 26-30.

[22]U.S. Department of Education, Office of Educational Research and Improvement, Center for Education Statistics, *The Condition of Education* (Washington, DC: 1986), p. 64. In making these projections, the National Center for Education Statistics used data from the National Education Association.

[23]'Eighty-nine percent of all schools of education offered some form of computer training to their students. See U.S. Department of Education, Office of Educational Research and Development, *Teacher Preparation in the Use of Computers* (Washington, DC: January 1986).

prepared to use computers in teaching. The American Association of Colleges for Teacher Education recently surveyed education faculty and students in 90 member institutions offering bachelor's, master's, or doctoral programs in education. Both education faculty and students were asked to evaluate the effectiveness of their teacher education program in preparing classroom teachers. On all but 2 of the 12 aspects of teaching in the survey, more than two-thirds of both groups considered students to be prepared to assume the tasks of classroom teaching. Yet this preparation did not carry over to teaching with technology. The faculty rated only 58 percent of the students as prepared to teach with computers, while only 29 percent of the education students felt ready to teach with computers.[24] (See figure 5-1.)

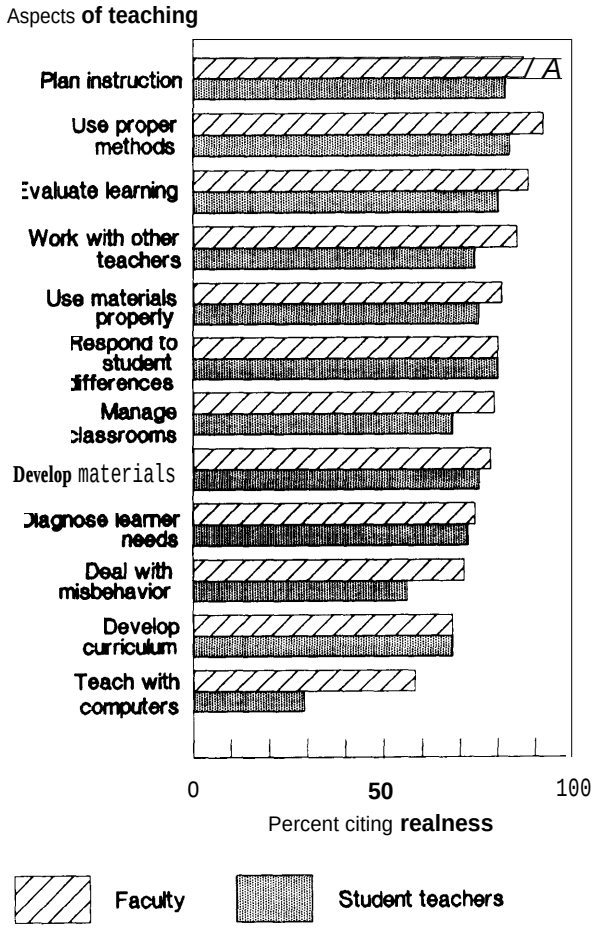
Factors Affecting Technology Training Programs

Several important changes over the past 10 years directly affect teacher technology training programs. Some have facilitated the technology training efforts, but others have created new problems that may explain why so many new teachers do not feel prepared to teach with computers.

Changing Technology.–Hardware and software have become easier to use, more powerful, and more useful in the classroom. More powerful and adaptive software means teachers have less need for programming skills. Computer training has become less technical overall. However, rapid technological change also creates problems for schools of education similar to those faced by teachers already in classrooms. As one dean at a major college of education said:

> The problem is how to prepare teachers for hardware that is not yet invented, for software that is not yet designed, and for curricula not yet imagined. It's hard to have a vision of what technology will be, but, as deans, we have to have a vision, and we have to realize that it will change.[25]

Figure 5-1 .—Readiness to Teach: Perceptions of Education School Faculty and Student Teachers



SOURCE: Research About Teacher Education Project, *Teaching Facts and Figures* (Washington, DC: American Association of Colleges for Teacher Education, 1987).

Varying Student Levels of Preparation.–Schools of education are faced with students whose computer backgrounds vary considerably. Since many more high school students now have at least minimal experience with the computer, the education schools' student population is more computer literate than was the case even 5 years ago. According to one estimate, approximately 60 percent of freshman entering college today have experience using the computer." Nevertheless, some education school faculty have argued that education majors may be less pre-

[24] American Association of Colleges for Teacher Education, *Teaching Teachers: Facts and Figures* (Washington, DC: 1987).

[25] Carl Berger, Dean of the College of Education, University of Michigan, Ann Arbor, quoted in "Education and the Challenge of Technology," proceedings of a Conference on Technology and Teacher Education, sponsored by the University of California, Berkeley and Apple Computer, Inc., August 1986.

[26] Judith A. Turner, "Familiarity With New Technology Breeds Changes in Computer-Library Courses," *The Chronicle of Higher Education,* July 22,1987, pp. 9, 12.

pared to use technology than their peers in mathematics, sciences, or business majors. [27]

State Regulations and the Education Curriculum.–State departments of education and professional organizations are establishing guidelines for what technology skills teachers need. For example, the Northwest Council for Computer Education prepared guidelines for teacher education in schools of education in Washington and Oregon. (See table 5-l.) The trend at the State level is to establish preservice education requirements. Currently, 18 States and the District of Columbia *require* all students in their teaching degree programs or those seeking certification to take a course on computer topics, or require that students demonstrate familiarity in using technology for instruction.[28] An additional seven States *recommend* that some preservice training be taken. [29] This leaves half the States currently neither requiring nor recommending technology preparation for new teachers. (See figure 5-2.)

Although formal requirements may force the development of new programs of study in educational technology, establishing new programs with education school faculty whose technology expertise is uneven or limited is difficult. Furthermore, some analysts believe that schools of education are overburdened with State regulations that can minimize creativity. Some States limit the total number of credits in the teacher licensure program. In Texas, for example, a maximum of 18 credits in education courses is allowed. Such restrictions make it difficult for schools of education to develop a curriculum that meets the requirements for initial licensure and still has room for technology training, unless educational technology is introduced as a central element in both methods and theory courses. Currently, this orientation is more the exception than the norm.

Table 5-1.—General Teacher Competencies in Technology

The teacher should:

1. **have an appreciation for** using the computer as a tool for solving problems;
2. have the experience of using computers in the learning of subject matter;
3. have knowledge of computer vocabulary;
4. be able to use the computer as a tool (using applications such as word processing, spreadsheet analysis, or database management); and
5. be familiar with computer hardware, including the everyday operation and use of a variety of machines.

SOURCE: N. Moore, "Preparing Computer-Using Educators," *The Computer Teacher,* **October 1984, pp. 48-52.**

Resources in Education Schools: Hardware and Faculty Expertise.—Although today's education students may have more access to computers in their overall university coursework than did their counterparts 5 years ago, the schools and colleges of education are often behind the rest of the campus in available hardware and faculty expertise. The education school or department has seldom received the large equipment donations from hardware manufacturers that other departments have. Education faculties have usually not received systematic training in technology use.

Trying to infuse technology into the traditional methods course remains a difficult task, due to faculty reluctance and inexperience with computers.[30] One university tackled this problem by re-

[27] Garv Bitter, Arizona State University, personal communication, October 1987.

"The State of California law reads as follows: "Commencing July 1, 1988, the minimum requirements for a clear teaching credential also include satisfactory completion of computer education coursework which includes general and specialized skills in the use of computers in educational settings, in accordance with regulations established by the commission.

(a) The Legislature hereby finds and declares that California's public school pupils need quality Instruction and support in the areas of computer education in order to develop the skills necessary for entry into an increasingly technological society. The legislature recognizes that computers and other technologies are an integral part of contemporary society and the state educational system.

It is the intent of the Legislature in enacting this section to provide a state law. [de standard for the preparation of educational personnel in the areas of computer education.

(b) For purposes of this section, "computer education" means the process of teaching pupils about computers.

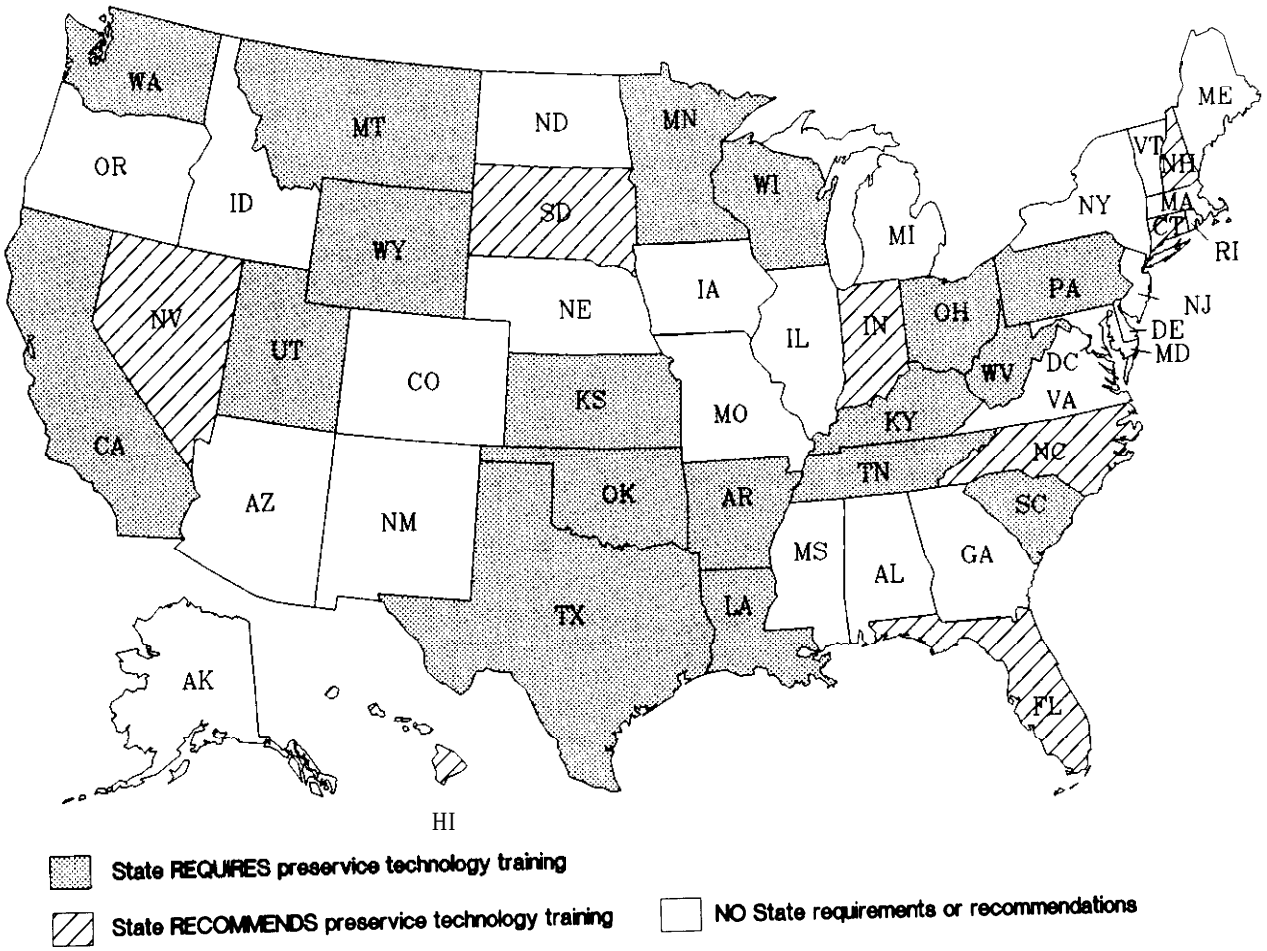
(c) The Commission on Teacher Credentialing, in consultation with the Superintendent of Public Instruction, may develop and disseminate voluntary standards for the training and performance of teachers and resource personnel in the area of computer education.

(d) The Commission on Teacher Credentialing shall study the effectiveness of the training and performance of teachers and resource personnel in the area of computer education, and shall submit a report on the results of the study to the Legislature on or before December 31, 1987." Assembly Bill No. 1681, Sec. 44261.7 and 44276, Oct. 1, 1985.

[28] OTA State Educational Technology Survey, 1987.

[30] Presentations by Gary Bitter (Arizona State University), Larry Hannah (California State University, Sacramento), and Charlotte Scherer (Bowling Green State University) at the 1987 National Educational Computing Conference confirmed this difficulty. They maintained that it is often easier to provide a separate course on using the computer, than to convince, train, and support methods Instructors in their content courses. Education students then lack models of teaching with the computer as a tool in various curricular areas.

Figure 5-2.—State Requirements and Recommendations for Preservice Technology Programs[a]



[a]Requirements for technology training are pending or under consideration in Alabama, Colorado, Maine, and Vermont. Requirements apply only to teachers in certain subjects in Minnesota, Oklahoma, South Carolina, Tennessee, Texas, and West Virginia.
SOURCE: Office of Technology Assessment State Educational Technology Survey. 1987.

leasing a professor of education from one of her courses for 1 year. Teaming up with methods instructors in all subject matter areas to introduce computer-related activities into existing education courses, she helped out with more than 60 such class activities. She indicated that a key to the success of this program was working with the instructor to first identify an important problem or topic and then using the computer as an aid to teaching that topic. Many of the methods instructors she worked with had never used the computer in their courses. As a result of their work with this computer-using colleague, they began to explore computer applications. As confidence and expertise increased, so did the probability of use.[31] Since teachers typically teach as they were taught, upgrading the technological skills of education faculty is an essential first step for preparing technologically literate entry--level teachers.

Student Teaching Experiences:—Internships With Computer-Using Educators.–One of the most important components of teacher training, and a focus of teacher reform efforts, is the internship

[31]Betty Collins, Associate Professor of Education, University of Victoria, as cited in Glenn and Carrier, op. cit., footnote 71 p. 26.

Photo credit *Houston Independent School District*

Placing student interns with computer-using teachers can provide role models for teaching with technology.

or student teaching period. If a teacher candidate interns in a classroom where the teacher uses technology creatively and regularly, the teacher intern sees technology's promise and problems in a real-life setting. Conversely, a student teacher who comes into a classroom and develops lessons utilizing computers can help bring technology to the experienced classroom teacher who has not worked with computers previously,

Where teacher education programs arrange provide schools with technologically-rich classroom environments (such as the professional development schools advocated by the Holmes Group), student teachers can experiment with technology in instruction, Such environments could also serve as settings for experiments where student teachers collaborate with mentor teachers, teacher educators, and researchers to examine a particular technological innovation.

An interesting experiment integrating technology into the student internship program is taking place at the University of Virginia, With a $1 million equipment grant from IBM, the University's Curry School of Education set up Teacher-LINK, a computer networking system to make electronic communication available in public school classrooms where the student teachers are working. Student teachers faced with running a classroom can communicate among themselves, with their cooperating teachers, supervisors, and with faculty at the University, lessening the isolation that many teacher interns feel. Both student teachers and education faculty are excited by a resource that lets the student teachers ask questions as they occur and solve problems in the real time of the computer network. The system also supports discipline-specific computer conferences, for example, in English and social studies, These are to aid students in developing curricula and lesson plans, and in learning classroom and subject-specific skills,

One of the more practical aspects of the network is the opportunity it offers student teachers to submit lesson plans and receive feedback from their cooperating teachers and supervisors:

> While tired teachers and interns may not want to stay for several hours after school giving and responding to feedback, they may find it easier to look at lesson plans, evaluations, and project ideas in the comfort of their own homes, after they have had dinner and rested a bit. Then, if the intern prefers to work until midnight, but the cooperating teacher chooses to go to bed early and review the uploaded unit outline at 7 am, neither wakes the other, and no time is lost in leaving telephone messages.[32]

The organizers hope this experience will encourage users to develop an interest in other applications of networking, such as conferences and collaboration on curriculum development and research. The computer-networking infrastructure supports activities ranging from elementary student projects, including cross-cultural writing networks, to advanced faculty research and collaboration. "

A computer network can also become an informal support system for beginning teachers, extending their training through the first year of teaching. Unlike doctors, who have supervised internships following medical school, beginning teachers are on their own once they graduate. Although the first year of teaching is a crucial period in teachers' development and can influence whether they stay in the profession, beginning teachers most often find themselves isolated, with few to turn to for advice.

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[32]Judi Harris, Curry School of Education, University of Virginia, Charlottesville, "Teacher-LINK: An Electronic Culture, " paper presented at the annual meeting of the American Educational Research Association, New Orleans, April 1988.

[33]For a full discussion of the uses of computer networks in K-12 education, see Earl Dowdy, t-; niversity of Illinois, Urhana-Champaign, "Computer Networks in Elemental\' and Secondary Education," OTA contractor report, October 1987.

As a means of providing first-year support to their graduates, the Harvard Graduate School of Education set up the Beginning Teacher Network. This network links 50 of Harvard's newest graduates with one another, and with several faculty members from the School of Education. They communicate through electronic mail and in forums on teaching specific subject areas, such as mathematics or psychology. Participants discuss classroom management and discipline, field concrete suggestions on the nuts and bolts of teaching, or talk about general education issues. Since the network's inception, roughly 3,400 messages have been transmitted, averaging some 110 messages a week. The participating beginning teachers, scattered across the country, value the camaraderie the network offers and the encouragement and practical information they receive from one another and from Harvard faculty. [34]

[34]Blake Rodman, " 'Hang in There, Bob': Notes for New Teachers Via Computer," *Education Week*, vol. 7, No. 32, May 4, 1988, p. 1.

INSERVICE TECHNOLOGY EDUCATION

Inservice education plays an important role in technology training for several related reasons. As cited above, most new teachers do not feel prepared to teach with computers. School systems must therefore play catch-up from the start. Furthermore, with technologies changing and applications varying so widely, it may not be either possible or desirable to expect that preservice education will ensure the effective use of technology by teachers. Just as preservice training prepares a teacher to begin teaching, so training in technology prior to entering the classroom may be best suited to providing introductory skills, enabling the new teacher to begin working with whatever technology exists in the classroom. Advanced training in applying new technologies can then occur through inservice and continuing education. Inservice training can also build on experiential learning, based on the teacher's specific classroom experience and needs. Thus, training for teachers should be seen as an ongoing requirement for professional growth.

Industry spends up to $30 billion a year on formal education to enhance and upgrade the work force. [35] Much of the teacher reform literature argues that education must make a similar effort.

Unique Characteristics of Inservice Training in Technology

Several characteristics and requirements of technology training distinguish it from other kinds of inservice training. Equipment is critical. It is possible to run an inservice session on a new reading or mathematics technique in a traditional classroom, but teaching teachers to use a word processing or gradebook program requires a computer. Furthermore, teachers can apply what they have learned in an inservice session only if they have access to the technology once the training has ended, both for gaining confidence through practice and for application in the classroom.

In addition, inservice training in technology must be sensitive to the concerns or anxieties with which teachers approach the use of technology. A teacher taking a course in other subject areas generally has some experience or background in the topic. But many teachers, especially those who consider themselves "B.C.''—before computers—have not yet worked with computers and admit to being "technophobic." Others had early negative computer training experiences. Sometimes programming was emphasized; sometimes the courses tried to cover too much, too fast[36] and had no relevance to their teaching needs. Several factors[37] contribute to a teacher's anxiety about computers; they must be taken seriously as they underlie whether or not a teacher adopts technology and how the teacher uses it in the classroom. (See box 5-E.)

[35]Anthony Carnevale, "The Learning Enterprise," *Training and Development Journal*, vol. 40, *No.* 1, January 1986, pp. 18-26.

[36]A study of teachers and administrators enrolled in a semester-long introductory course on computer applications found that for those with no prior experience, the decline in anxiety did not appear until after some 30 contact hours with the computer. See Gerald Bracey, "Still Anxiety Among Educators Over Computers," *Electronic Learning*, vol. 7, No. 6, March 1988, p. 20.

[37]See, for example, F. Williams and V. Williams, *Microcomputers in Elementary Education: Perspectives on implementation* (Belmont, CA: Wadsworth Publishing CO., 1984).

Photo credit: Paul Foldey, Lesley College

For many teachers, especially those who consider themselves "B. C." (Before Computers), learning to teach with computers is a challenge. Sensitive training, time to practice, and support from peers are the best antidotes to computer anxiety.

Factors Contributing to Effective Inservice Computer Education Programs

Studies[38] examining inservice computer education programs have identified several instructional practices that contribute to effectiveness. (See box 5-F.) In conjunction with the Minnesota Technology Demonstration Site Program, [39] part of the Minnesota legislature's educational technology initiative, a comprehensive review of inservice technology training activities was conducted. This evaluation covered 3 years (1985 to 1987) and involved 17 technology demonstration sites. Although inservice activities varied widely across the sites, evaluators found that there was a progression of inservice technology topics at most sites. These were characterized as:

- "Awareness" stage: large group workshops run to acquaint teachers with a general overview of how technologies work and to alleviate anxiety;
- "Overview" stage: workshops that delivered additional detail on how particular technologies work and usually provided examples of the application of technology to particular subject matter areas;
- "Topical" stage: a more focused approach (for example, using computers in social studies) with fewer participants;
- "Adoption/implementation" stage: more focused with intense work by each participant; and

[38] B. M. Stecher and R.S. Solorzamo, *Characteristics of Effective Computer Inservice Programs* (Pasadena, CA: Educational Testing Service, 1987).

[39] See D.L. Morehouse et al., "Technology-Related Inservice Education Findings, Issues and Recommendations: An Analysis Based on Evaluation of Minnesota's Technology Demonstration Program—Quality Evaluation and Development," a report of the Minnesota Department of Education, 1987.

Box 5-E.—First Encounters With Computers: Some Teacher Concerns

- **Fear of Uncertainty.**—Teachers have been trained to master and fully understand the tools and materials they work with in class. It requires a change in attitude to say, "I don't understand how this works, but I can see what it can do and that's enough for now." Furthermore, teachers must be in charge in their classrooms. Not being an expert may lessen the teacher's authority. Teachers have legitimate fears of embarrassing themselves in front of students who may be delighted to see that the teacher does not know everything after all.
- **Concerns Regarding Changes in Teacher/Student Relationships.**—Computers can motivate students, reinforce basic skills, keep records, focus attention, simulate environments, calculate, and give immediate feedback—all things which teachers themselves expect to do. Teachers see that students are often more enthusiastic about working with computers than with the teacher. Computers also can store considerable data and thus may "know" more than the teacher about certain things. Computers alter roles and relationships, especially when some students know more about the computer than the teacher, and when students are given responsibility for helping to run the class and for teaching other students. While some teachers welcome these opportunities to restructure the classroom and allow for peer expertise, other teachers are uncomfortable with these changes.
- **Concerns Over Accountability.**—Computers make it easier to meter productivity by centrally kept records. Student scores can be monitored and teacher success can be checked against these scores. Even sophisticated computer-using educators worry how the problem solving skills students develop with computers can be measured. As one teacher said, "For me there is a real concern that no one knows or will recognize the work I have done with students in this most important area."

SOURCE: Office of Technology Assessment, 1988.

- "Integration" stage: characterized by fine tuning of curriculum materials that use technology or guided assistance in integrating certain types of technology into a teacher's lesson.

Box 5-F.—Factors Contributing to Effective Inservice Computer Education Programs[1]

- **Appropriate balance between lecture and guided practice.**—A cycle of minipresentations, demonstrations, and practice sessions appeared to be the most effective approach.
- **Detailed curriculum guides and lesson plans.**—Well-planned materials were a visible component of the inservice programs.
- **Clear and relevant objectives.**—Teachers needed to feel they had a clear understanding of what they would learn and of their responsibilities.
- **Lesson-related materials and handouts.**—Such materials appeared to free teachers from extensive notetaking or reliance on computer manuals.
- **Inservice lessons linked to instruction.**—Teachers liked specific help on preparing materials and experiences for their own students, things they could go back and use with their students the next day. Teachers appreciated and learned from good modeling on the part of the trainers.
- **Peer interaction.**—Communication among participants during hands-on sessions was particularly effective.
- **Strategies for teaching heterogeneous classes.**—Trainers who had ways to deal with students of differing levels of prior knowledge and anxiety were more effective. For example, some trainers used teaching assistants effectively in helping less or more advanced students.
- **Followup.**—The impact of training was much stronger when followed up. Typically, teachers would come back together and report on their use of the computer application in the classroom, and share experiences.

[1]B.M. Stechner and R.S. Solorzamo, *Characteristics of Effective Computer Inservice Programs* (Pasadena, CA: Educational Testing Service, 1987).

Teachers reported that they preferred learning about technology from other teachers or those who understand the settings in which they work (including the limitations and constraints of those settings). The teachers said they wanted access to followup support, and access to equipment and software during and after the inservice training. Seventy-eight percent reported that they participated because they were curious, had specifically requested the topic, or preferred a technology-related topic to other non-

technology inservice courses that were available. Nearly 80 percent of the teachers in the study said that they had used the training application in their classrooms.

Interviews with technology site directors or district superintendents indicated they believed strongly that teachers should be involved in the planning of technology inservice activities and that such activities must be based on teachers' needs.

The evaluators concluded that, for inservice education to be a powerful force in moving technology into classrooms, it must have a strong practice or "hands on" component, must be taught by credible sources (most notably other teachers), must be suited to the competence level of the teachers, must include followup support and guidance, must be sufficiently long, and should include extensive instruction in the use of computer software tool applications.

State and Local Efforts

The local school district is the key provider of all inservice training for teachers, and this role carries over to inservice training in the use of technology. Districts use a variety of course providers, differing approaches, and funding sources. Although the State and/or the Federal Government may provide some funding for inservice training, the district decides who will be trained, how, and where. Providers may include local universities, regional resource centers, intermediate school districts, local technology departments, hardware companies, software developers, and professional organizations. The training can be formal or informal, long term or just a few hours, ranging from a full program of studies (encompassing a number of courses leading to an advanced degree or special certificate), to short courses on a particular software tool, attendance at a technology conference, or teacher-to-teacher sharing right in the classroom. The technology can be both the focus of training and the training source, as happens with electronic bulletin boards, computer conferencing, and courses broadcast via satellite from distant locations. Local district monies constitute the principal source of funding, with commitments of State and Federal resources also targeted to teacher training activities.

States play a significant role in furthering the effective use of technology. In identifying the challenges and issues critical to technology in schools, the National Governors' Association recommended: "... that at least 10 to 20 percent of State funds allocated for acquisition of various machines should go for training programs. The task force strongly believes that States must make a greater commitment to support training programs."[40] While State support has already been a significant factor in the growing use of technology, it is likely to be even more so in the future. State influence emanates from direct and indirect funding, technical assistance, institutional arrangements, and regulations or recommendations.

OTA's State Educational Technology Survey found that 41 States have a Technology Coordinator or an Office of Technology. Thirty-three States and the District of Columbia provide some funding for teacher training in technology. This support comes from State funds earmarked specifically for technology training in over half of these cases, but States may also use their general State aid to education, professional development funds, monies funneled to regional centers, or training funds which the State has received from special Federal programs, such as Title II funding for mathematics and science teacher training, Chapter 1, Chapter 2, Vocational Education, or Special Education monies.[41] One estimate for State spending for teacher training in technology showed an increase from $10 million in 21 States in 1986 to a total of $25 million in 25 States in 1987.[42]

In the OTA survey, States reported wide variations in funding—from as little as $20,000 to a high of$15 million per year (see appendix A). Most States have, however, been unable to allocate the level of financial support for teacher training in technology that they would prefer. Those which do not directly support training from State funds find other ways to assist teachers to use technology, as, for example, in their software evaluation centers or State purchase plans for hardware and software that make

[40] National Governors' Association, Center for Policy Research and Analysis, *Time for Results: The Governors' 1991 Report on Education* (Washington, DC: 1986), p. 132.
[41] OTA state Educational Technology Survey, 1987.
[42] *Electronic Learning*, "Educational Technology 1987," vol. 7, No. 2, October 1987, p. 39.

it possible for teachers to purchase materials at reduced cost. Many States run annual technology conferences, while others put on workshops or support regional training efforts. California was an early initiator of the concept of regional Technology Education Computer (TEC) Centers, to provide a network of resources for training and technical assistance all across the State. California's TEC Centers provided a structure for coordinating services and resources. Although these centers played a major support role, their State funding was eliminated in the 1987 budget by the Governor. Some TEC Centers have continued with reduced funding, most of it provided by local districts or other non-State support.

In contrast, New York State's Teacher Resource and Computer Training Centers have expanded dramatically. In 1984, the New York State legislature created a network of regional teacher resource and computer training centers to improve teaching skills and train teachers in the educational applications of computer technology. Teacher organizations have been instrumental in setting up the centers, most of which are housed in local schools, and teachers chose the special focus on technology training. In 1987, the State legislature voted to increase funding for the centers from $12.5 million to $15 million, in order to support the existing 74 centers and add 17 new centers. The centers are linked electronically, enabling the teachers in one center to communicate with teachers in other centers, either informally on electronic bulletin boards, or more formally in computer conferences organized by the teachers on topics of shared concern (for example, dropout prevention strategies).[43]

Most States recommend that all teachers participate in inservice courses on teaching with technology; three require it. (See figure 5-3.) Minnesota requires that every teacher in the State take at least one computer-related course and West Virginia requires that teachers in certain academic disciples take a computer course. In Utah, all current teachers must demonstrate the ability to use technology in instruction. Other ways to encourage teachers to use technology include the unusual approach taken by the State of New Hampshire. The State provided 1,950 teachers with a personal computer of their own to use at home for 3 years. With the computer they received software and training to enhance their personal productivity. The State is gambling on the fact that, as teachers become comfortable with computers by using them at home, they will see ways of applying them to their teaching and adopt technology as a teaching tool with enthusiasm and a measure of expertise.

[43] In addition to these centers, many of the State Intermediate units and teacher training Institutions not funded as teacher resource and computer training centers also offer programs of technology training.

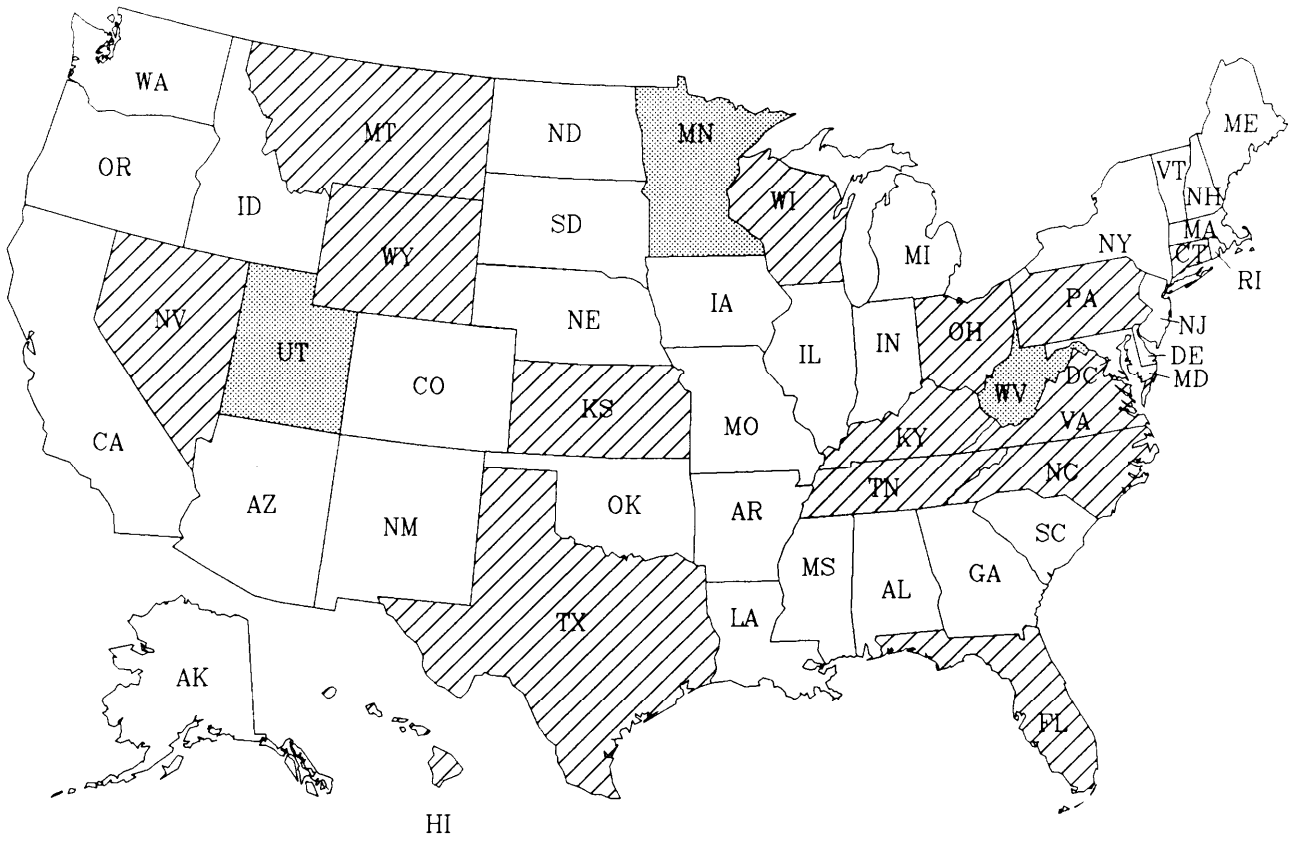
District Activities

While States play a large and growing role in providing inservice technology training, the major source of such training is the school district. The most consistent professional education experience for a teacher is the inservice program sponsored by the district. At least once during each year all teachers attend some type of inservice workshop on a topic of their choosing or of the district's sponsorship. Although considerable resources have been allocated to inservice training in technology, it is difficult to estimate the overall level of funding support since districts may not separate technology

Photo **credit:** *Computer Learning Month*

Some of the most effective teacher training comes through support from more experienced teachers in informal sessions where new strategies can be practiced before use in the classroom, as seen here at the Packer School, Brooklyn, New York.

Figure 5-3.—State Requirements and Recommendations for Inservice Technology Programs[a]



[a]Requirements for technology training are pending or under consideration in Alabama, Colorado, Maine, and Vermont. Only teachers of certain subjects are required to take a computer course in West Virginia.

SOURCE: Office of Technology Assessment, State Educational Technology Survey, 1987.

courses from overall professional development support.

In a series of OTA case studies[44] of various approaches to technology training for teachers, three school districts were studied (Houston Independent School District in Texas, Albuquerque Public Schools in New Mexico, and Jefferson County, Alabama). In each of these districts, teacher training was a central part of the technology implementation plans.

[44]For a discussion of seven case studies of State, county, district, school level, and industry supported teacher training, see John Strange et al., "Alternative Approaches to Developing a Cadre of Teacher Technologists," OTA contractor report, December 1987.

Regarded as one of the Nation's leading districts in educational technology, the Houston Independent School District (HISD) established the first Department of Technology for a local school system in 1982. The goal was to assure that all technology planning and services to HISD schools would be centralized and coordinated. As a part of this broad effort, the position of Teacher Technologist was created. Each of the 240 teachers who entered the program received 296 hours of technology training conducted by the department. To qualify for a $2,000 bonus, they take an additional 30 hours of updated training each year. The Teacher Technologists serve 90 percent of Houston's schools, and spend 60 per-

cent of their time in the classroom, teaching the State-mandated computer course or helping to integrate technology in other content areas. Additional school-wide duties include training other teachers, parents, and administrators; running student computer clubs and other activities; and coordinating purchases and allocation of hardware, software, and resource materials. The centralized approach to Houston's technology program is currently being reevaluated under a new superintendent. HISD's 1986-87 technology budget excluding hardware appropriations was $2.3 million, a 70 percent reduction from that of the previous year, when $7.7 million was made available.

Albuquerque adopted a less centralized training approach. The district established a partnership with two local institutions of higher education to provide a 64-hour course sequence for interested teachers. The training program, Computing for Teachers, focuses on mastery of three core applications: word processing, database management, and LOGO, with emphasis on developing strategies for integrating technologies across the K-12 curriculum. The course sequence can be taken for credit at the University of New Mexico at the teacher's expense, or at the Technical-Vocational Institute, where the fee is paid by the district at a cost of $5 per trainee. Both courses use the same materials and teachers from the Albuquerque Public School staff. Approximately 75 percent of the teachers in the system have completed this computer training cycle.

The Jefferson County study provided a very different model, involving limited local funding but substantial support from local businesses and national hardware and software companies. An ambitious multimedia training program involved after-school workshops and continuing support from the county's Office of Staff Development. The goals of the program were to help teachers and students (who were allowed to participate in the workshops) incorporate a variety of technologies (radio, TV, desktop publishing, video, electronic keyboards, and telecommunications) into classroom presentations across a range of curricular areas; to provide hands-on experience in creating media; and to teach media production as a critical thinking process. Approximately 100 teachers from 13 county schools participated during the 1986-87 school year. All training was conducted by the program's initiator who received $5,000 for the 9-month project from Title II funds committed by the Jefferson County School District. Because he volunteered the rest of his time to the project, and the teachers attended the training voluntarily on their own time, no other school system funding was involved. National and local corporate sponsors donated equipment, software, and other materials valued at more than $50,000. Other local sponsors, such as the Alabama Power Co., contributed space and support for multimedia fairs that showcase teacher- and student-created materials.

While these three examples show the range and variety of local district approaches, there is no one best model which school districts adopt in the scramble to keep pace with technology.

Training From Other Sources

Computer companies, software developers, and professional organizations also provide training and support for teachers to use computers in their curriculum. On a more informal basis, classroom teachers give each other assistance and support, sometimes through informal peer assistance in the school, as well as across town or across the continent via the technology itself when teachers participate in networking activities such as electronic mail, information sharing via electronic bulletin boards, computer conferencing, and subject-oriented workshops. Sometimes schools even set up systems where students with computer expertise tutor teachers.

Industry Efforts

Computer companies have a direct economic interest in training. It makes good business sense to instill in teachers a sense of loyalty to a particular type of computer. Training efforts therefore are seen as one cost of selling computers.

An early entrant to the training arena was the Tandy Corp., which introduced many teachers to computers through seminars and workshops in Radio Shack outlets. Early efforts reached more than 400,000 teachers. Tandy currently offers training both at the school site and in Tandy training centers, providing custom workshops to meet the needs of individual districts or State agencies that are working closely with Tandy .45

[45]William Gattis, vice president, Radio Shack Education Division, personal communication, Feb. 22, 1988.

One comprehensive effort at computer training for educators was the 1984 joint venture between the National Computer Training Institute of Fremont, California, and IBM to provide training on the IBM PC Jr. (See box 5-G.) Particularly farsighted was their concept of giving teachers a computer of their own for home use, enabling the teacher to feel comfortable through gradual mastery, and eventually to appreciate the computer as a tool that could also be applied at school, Many of the major computer companies active in the K-12 market have now instituted educators' discount programs.

IBM has also participated in college and university discount programs by making computers and related technology available at reduced prices. As noted above, IBM is supporting demonstrations of telecommunications networks for student teachers (University of Virginia's Teacher-LINK) and first year teachers (Harvard's Graduate School of Education's Beginning Teacher Program). IBM also provides implementation workshops for school districts that have purchased IBM software, and has conducted extensive teacher training efforts for districts that have implemented the *Writing to Read* pro-

Box 5-G.—IBM/National Computer Training Institute Cooperative Training Plan

In August 1984,97 pairs of trainers from 49 States and the District of Columbia, chosen for their experience in using computers, were brought to the University of California at Berkeley for 2 weeks of intensive training at IBM's expense. The training emphasized the use of the IBM PC Jr. and applications including four components of the IBM Assistant Series of administrative programs (word processing, report writing, database development and management, and graphing), *Multiplan*, BASIC, LOGO, telecommunications, and software evaluation. In return for the commitment of 2 weeks training, IBM provided each school's pair of trainers with 17 IBM PC Juniors, monitors, graphic printers, software, modems, carrying cases, and a variety of additional peripherals. The sponsoring schools agreed to provide a secure, air-conditioned laboratory for 15 sets of the equipment, to use the laboratories for computer-related instruction during the school day, and to make the laboratories available to teachers for evenings, weekends, and summer training sessions. The two participating teachers were each given a PC, monitor, and printer for their own use at home. In attempting to take a bite into Apple's growing share of the K-12 market, IBM was willing to invest a substantial sum. Estimates for the hardware and software alone were $3 million. The cost of the Z-week training session, borne by IBM and the National Computer Training Institute (NCTI), was at least another $60,000. The goal was to have these school sites serve as models for their local area and to encourage other schools to purchase the PC Jr.

There was to be a second stage to the initiative, which called for IBM. to market the PC Jr. to teachers and educators for their personal use at a very low-price, perhaps as little as $500 per system. With each system, a teacher would receive two coupons, one good for 7 free hours of training in personal computing at one of the NCTI sites, and the other worth a substantial rebate on the 40-hour NCTI course designed specifically for classroom teachers. The theory was that, in order to get teachers to use computers in the classroom, teachers first had to become familiar, competent, and comfortable with the hardware and software by having computers in their homes.

The second stage never got off the ground, and NCTI went out of business in September 1985. Several reasons have been suggested for NCTI's failure, including NCTI inexperience in dealing with the school market and the competition from computer courses offered for credit at local colleges, sometimes at a lower cost than the noncredit NCTI course. Other problems included difficulties with the PC Jr. keyboard, the PC-DOS operating system which required a complex form of loading and disc swapping, and lack of software for the PC Jr. Additional problems included IBM's legal concerns over the potential for an unfair trade practices suit if the PC Jr. were to be sold to teachers at the proposed below market cost of $500. Potential buyers were also frightened off by the persistent rumors, eventually substantiated, that the PC Jr. would be withdrawn from the market. The program suffered a final tragic loss on August 2, 1985 when Phil Estridge, the IBM executive most responsible for the IBM/NCTl initiative, was killed in a plane crash, With his death, support for the program ended altogether.

SOURCE: Office of Technology Assessment, 1987. For a fuller description of this and other case studies of teachers training see John Strange et al., "Alternative Approaches to Developing a Cadre of Teacher Technologists," OTA contractor report, December 1987.

gram. IBM has also provided equipment for use at technology demonstration centers.

Apple has supported teacher training efforts through a variety of company policies. To meet the needs of districts who want training from a vendor, Apple has typically contracted with private corporations and consultants to provide teacher workshops. For example, Apple has contracted with the Minnesota Education Computing Corp. (MECC) to provide workshops to school districts. This cooperative relationship has worked because benefits accrue to each of the parties involved. Apple has resources to subsidize some of the cost; MECC has the expertise to design, and trainers to conduct, the workshops; and the district provides facilities and release time for the teachers as well as some of the training cost.[46]

Computer companies are also supporting education through advisory groups made up of experts from education and industry who meet to discuss education and technology. For example, Apple's Education Advisory Council held a meeting in November 1985 focusing on teacher and administrator training. This was followed in August 1986 by a gathering of 90 deans of education schools, directors of teacher education, researchers, and industry experts to discuss technology and teacher education. One of the recommendations stemming from the Conference on Technology and Teacher Education—to establish partnerships among universities, industry, and schools to respond to the challenge of technology in education—has taken root in the efforts of several hardware manufacturers. The Apple University Consortium, which links 32 institutions of higher education for information sharing and provides large discounts on equipment, has been particularly beneficial to schools of education as they set up computer laboratories.

American Telephone and Telegraph (AT&T), a recent entry onto the education scene, has developed a cooperative relationship with Indiana University's School of Education. AT&T provides equipment and technical support for the reconfiguration of the school's technology program. AT&T will provide funds for the retraining of the faculty and for the development of educational programs for both undergraduates and graduates in education. This arrangement will give Indiana's School of Education both the latest technology from AT&T and the funding needed to utilize equipment effectively in redesigning the curriculum.

Software Developers Training Efforts

Education software developers are also interested in helping teachers use the technology, especially to encourage teachers to use the software sold by their own company. This training, too, can take many forms. The most basic gives guidance on how to use software packages in the curriculum and is similar to the printed manuals teachers receive with a new textbook series. For example, in a series of software packages for simulations based on historical and contemporary issues, each program package includes a teacher's guide with reproducible materials, detailed lesson plans, and individual reference books. The materials are designed to help the teacher use the simulations in a way that gets the most out of the software, while making it easier for the teacher to integrate the materials into the curriculum.[47]

Other software producers make videotapes available to assist teachers to use their products. For example, Sunburst Communications has developed videotapes to illustrate how a teacher might use its products, many of which involve problem solving activities and are more complex to use than traditional drill and practice programs. The tapes show actual classroom applications and provide clues to the teacher on how to organize the students and how to proceed through the lessons. The materials can be used by an individual teacher, by district training personnel for group inservice activities, or by the software sales representative in providing inservice education.

Some software developers give away free software after teachers have attended a course on how to use that software in the curriculum. Other developers (for example, Mindscape, Inc.) are providing work-

*[b]Minnesota Education Computing Corp. estimates that it costs $200 to $300 per day, per teacher to conduct its training. School districts at most are willing to pay $100 to $150 per day. Because vendors like Apple stand to gain from teachers being trained to use their machines, vendors are willing to subsidize some of the cost of the training, thus reducing costs to the district. Don Rawitsch, Minnesota Education Computing Corp., personal communication, 1987.

[47]Tom Synder Productions, Cambridge, MA, *Decisions Decisions Series* (Software series, 1986).

shops on computer applications in content areas (social studies, writing, and mathematics), using a variety of software, not just their own brands. They are gambling that, with increased training, teachers will become more informed and enthusiastic users of computers. This enthusiasm would then pay off in increased software sales, including sales of their company's titles.

As more and more teachers use technology, hardware and software companies may want to consider joint efforts with State education agencies, regional teacher resource providers, and universities to develop workable strategies to meet the needs of training teachers in emerging technology applications. Substantial efforts will be required in the short term and over the long term to accomplish technology integration across the curriculum. It is clear that each training provider has limited resources; there may be ways to combine these resources more efficiently and effectively.

Informal Training Via Computer Networks[48]

Elementary and secondary schools are also beginning to make use of the communications capabilities of computers for electronic mail, information retrieval, and computer conferencing. With an investment of $2,000 or less, a school can participate in using a network, assuming that the school already has a telephone line. Costs vary over time depending on the types of activities in which the school participates, long-distance charges for hookup, and subscriptions to various services. These costs are proportional to usage and largely under the control of school administrators.

While State, local, district, and commercial networks are proliferating, it is difficult to estimate how many teachers and students use them. Potentially thousands of elementary and secondary schools and millions of students could engage in joint activities using computer networking. Moreover, teachers and administrators could share information across, as well as within, the traditional institutional boundaries. This opens up significant new opportunities for collaboration, research, and information sharing. Barriers of geographic isolation, socioeconomic status, and physical handicaps can be overcome.

[48]For further discussion, see Dowdy, op. cit., footnote 33.

Electronic networks can help to solve one of the most basic problems in K-12 teaching: the isolation of the classroom teacher. Discussions and sharing of curriculum ideas, materials, and methods are facilitated by the immediacy of the network. For the elementary school teacher in particular, who spends all day, every day, in a classroom with children, the opportunity to reach other professionals outside the four walls of the classroom can be liberating and stimulating. Whether the novelty of this effect will wear off with experience is debatable; nonetheless, it is hard to envision teachers closing the windows to a wider world once they have been opened through electronic networking. The capabilities of networks are just beginning to be explored by teachers. Box 5-H shows an informal computer conference initiated by one teacher looking for ideas and curriculum support from other teachers, an example of what can be done by innovative teachers hooking up via telecommunications.

Other Informal Sources of Peer Support

While the modem can connect teachers in different schools, the computer itself can help teachers within a school work cooperatively. Perhaps because of the computer's novelty, many teachers feel comfortable asking other teachers for help with computer applications, even though teachers do not so readily ask peers for help with normal course work.

Much is to be gained when teachers open their classroom doors to the enrichment other teachers offer. In some cases, this can be formalized. Over a 5-year period, every secondary teacher in Pittsburgh's Schenley High School spends an 8-week "sabbatical" working with master teachers at the school.[49] The National Education Association has employed the concept of teachers teaming together in their new Christa McAuliff Institute for Educational Pioneering. The 20 teachers chosen for the first Institute were selected on the basis of applications suggesting uses of new technologies in the classroom. Each application had to be submitted by a two to four member team, who will work together on their proposed technology application at their home school.

[49]Robert Pearlman, Boston Latin School, Boston, MA, personal communication, December 1987.

Box 5-H.—Excerpts From a Computer Conference on the MIX Network: "The National Student Book Search"[1]

The following message was sent via the MIX Computer Conference, "The National Student Book Search," to interested parties. The conference was initiated by Steven Pinney, a teacher.

The variety of favorite classroom literature can be explored by the building of a national literature database. This project's focus is the use of both cooperative learning and critical thinking skills as they apply to the literature read daily in America's classrooms. . . . The focus of this project is the answer to this question:

What piece of literature does your class feel is their favorite?

The answer to this question will be sent to MIX via a format similar to a computer software database and incorporate information on the school, the students, and the literature selected.

If you have writing/thinking activities that you feel would be of interest to other teachers in this project, please offer them in **2.Suggestions**. s.pinney

response: from t.evans:

Don't they have to read an awful lot of books to make their choice valid? Our school is going to a thematic approach to learning as well as a totally literature based program. . . . We first coordinate our science and social studies curriculum—then select novels to fit the theme we are teaching—to do a really good job of teaching a novel takes several weeks . . . but at 5th grade it is hard for many to sit still and read.

response from s.pinney:

Welcome, t.evans . . . and I agree it is a REAL challenge to support so much reading, but I have found that many teachers are not as fortunate as you to have such dedicated cooperation as you have mentioned. I, for instance, work without the option to do such exciting planning and feel the worse for it. What HAS worked in this project, though, is to set the problem up as a class project that we work TOWARD . . . thus we are now forming groups to read say 5 or 6 different books and present their findings to us all so we may begin to narrow the field. By November we hope to have a candidate list of maybe 10 suggested good books to regroup, reread and narrow to 5 . . . and so on. Does this help at all?

response from r.conner:

Steven: My timeline . . . will have to be mid-January. Will that still meet and mesh with your timeline? Count me in, if so.

response from s.pinney:

Welcome Raleigh: My timeline is poured in jello as I teach 7th grade and with plays, track meets, the flu, makeup work and ski trips I have a herk of a time committing to anything firm. We plan . . . to build a database of general categories and comment areas and then we will get to work. January sounds refreshingly sane! Let's do it! Steven.

response from k.yalda

Hi Steven: I popped in to see what this conference was about. It sounds great and definitely worthwhile. But at the risk of exposing my ignorance, I'm not sure I understand just what the project IS. Is "great books" just a phrase you're using, or are you referrring to the classics in literature? could you explain the project a little more thoroughly for us slow learners! Thanks, Kim.

(and so on.)

[1]McGraw-Hill, Inc., Eden Prairie, MN, MIX, The McGraw-Hill Information Exchange for Educators.

POLICY IMPLICATIONS

Clearly, the teacher is central to full development of technology use in education. Teachers are not the problem, and without them there can be no solution. Most teachers want to use technology, but few have found ways to exploit its full potential. The technology will not be used, and certainly not used well, unless teachers are trained in the use of the technology, provided goals for new applications, supported in doing so, and rewarded for their successes in meeting these goals.

OTA finds that there are players on many fronts who have a stake in providing what teachers need now and in the future, and new technologies themselves can become tools for training and support.

Teacher Education: A Place to Begin

Training in the use of technology will need to be a part of the preparation every entry-level teacher receives. Several factors explain why this training need has not been met: lack of expertise of many education school faculty; insufficient and outdated technology resources; and incomplete understanding and attention to how teaching roles may change as technology changes the teaching environment. Preservice technology support will need to address a number of factors.

Training for Education School Faculty.– Courses or workshops can bring college of education faculty up to speed in current applications of computer technology in education. Possible sponsors include: Federal agencies, through programs such as the Department of Education's Fund for Improvement of Postsecondary Education, or the National Science Foundation; State Departments of Education; professional associations such as the American Association of Colleges for Teacher Education and the National Council for Accreditation of Teacher Education; or industry,

Equipment.–Because of the costs of maintaining up-to-date equipment and software, schools of education will need help from both the private sector and the Federal Government. Improved computer facilities in schools and colleges of education may require Federal support comparable to ongoing Federal support for supplying the most up-to-date facilities in university science laboratories. In addition, special institutional arrangements could be made with industry similar to the support provided to other academic departments in the university. Just as industry has encouraged familiarity with and loyalty to hardware brands and software packages among undergraduates and graduates going into science and business, so too will they benefit from supporting education students' use of their hardware and soft ware as a tool they will expect to use in teaching.

Undergraduate Competencies.–Schools of education need to cooperate with the college or university at large to establish basic levels of technological competencies for students. A substantial portion of the undergraduate program for teaching majors takes place outside the school of education. There may be university resources that can contribute to students' understanding and competence with technology. At the same time, inappropriate or negative experiences with technology can create barriers to future use in education. How best to nurture computer-using educators can be addressed in a variety of ways, at different institutions.

Teaching Internships.—Schools of education and the local school systems they serve could work together to develop teacher internships on the model of teaching hospitals. These settings make it possible to test and apply state-of-the-art technologies by the new practitioner under assistance of the experienced teacher. The school provides the real-world setting for the prospective teachers, and they in turn can bring to the classroom the most up-to-date information on educational technologies and their applications. Experimental schools could also provide research internships for both prospective teachers and education researchers.

Research and Pilot Projects.–Schools of education could be in the forefront of research on how to effectively prepare technologically literate teachers and how to upgrade their skills. Currently, the research base in teacher technology education is very weak. Federal programs can stimulate a wide range of activities, targeting funds for various programs and areas of the curriculum, for example, science and mathematics education, education of at-risk students, and special education. In supporting a number of technology demonstrations, States can provide incentives for local districts to work directly with university educators and private industry.

Keeping Up With Technology: Inservice and Informal Training

Training in the use of computers and other technologies should be continued throughout a teacher's career. If teachers are to move from the simple use of technology to more integrated instructional approaches, innovative inservice programs accompa-

nied by followup support will be needed. Recommended components include the following:

Incentives.–A wider range of incentives will be needed to encourage teachers to learn about and use technology. School boards have traditionally encouraged teachers to gain new skills by providing higher pay for advanced degrees. However, more than half of all teachers in primary and secondary schools already hold a master's degree or higher, so this traditional approach will not be enough. Additional incentives could be developed to encourage teachers to stretch beyond their current levels of expertise or to encourage technologically experienced teachers to train their colleagues and provide support for them. Extending the teacher-to-teacher connection is a strategy that could bring dividends on all sides. A wide range of options is possible:

- summer employment;
- release time during the school day;
- additional pay for technological expertise;
- a computer for every teacher to use at home or at school;
- grants for software acquisition for the classroom;
- sabbaticals with universities, hardware manufacturers, and software developers to conduct research or provide advice regarding educational applications;
- paid participation in professional conferences; and
- increased status as master teachers or lead teachers in the school, with corresponding authority and remuneration.

Incentives are important means of holding trained teachers in the school systems that have invested in their technology skills. These individuals are in great demand, and higher paying positions in other school systems or in the private sector may drain the best teachers if extra support is not provided.

Communications.– With technology changing and expanding rapidly, there is a clear need for the Federal Government to assume a broader role in disseminating educational technology information to teachers across the Nation. Technology can be a medium for communications. While a variety of computer networks have been set up by some districts or States, none has a national perspective. A central clearinghouse or collection of regional networks would be a useful way to disseminate information about research, models, and innovative or advanced approaches to technology use and training. Because there is now no central clearinghouse, redundancy occurs, common mistakes are repeated, and few learn from the work of others.

School districts can make up-to-date telecommunications accessible to their staff. Electronic networks could be supported, by installing phone lines in classrooms or laboratories, and by subsidizing subscriptions and connect costs on bulletin board systems, databases, and other resources which can keep teachers informed and in communication with their colleagues and experts around the country. Telecourses and other distance learning options for teachers (as well as students) are other mechanisms to make information available.

As use of telecommunications networks expands, the question of costs will become a critical factor. There may be a need to examine ways to subsidize or provide reduced rates for educational use.

Models and Pilot Projects.–The Federal Government could support projects that are models of technology training for States and districts or institutions of higher education. Principals of effective technology training, at the inservice level especially, have been identified and confirmed by research. But while these principles seem solid, the research base to guide decisionmaking about technology training must be expanded. Several educational institutions have developed technology education programs that attract teachers from across the Nation.[50] These efforts provide a rich source of expertise for further development.

Federal Leadership

The Federal Government, particularly the Department of Education, could provide an important leadership role. Technology initiatives begun in the early 1980s have all but disappeared. Many of the pioneering computer-using educators were originally trained through direct Federal support via summer institutes or special courses offered by the National Science Foundation (NSF) or Department of Education. Precollege Teacher Development in Science programs were eliminated by the zero funding of the

[50] See Lesley College case study in Strange et al., op. cit., footnote 44.

Science Education Directorate (part of NSF) in 1982 and the elimination of categorical grant programs with the Educational Consolidation and Improvement Act (ECIA) of 1982. Although the Education for Economic Security Act (EESA) provides support of teacher training in mathematics, science, critical foreign languages, and computer learning, most efforts have focused on mathematics and science. Teacher efforts at NSF have also focused on applications in mathematics and science, leaving humanities teachers without Federal training support. If these NSF efforts were expanded to include all types of teacher training that utilizes technology, much greater funding would be required for the Teacher Enhancement Program,

Yet States and districts continued to support teacher training in technology on their own, channeling their ECIA or EESA block grant funds into the purchase of hardware and software and teacher training in their applications. They have also provided extensive financial support for these activities under their State and local operating budgets. As a result, there is much activity, but it is highly varied in size and scope from State-to-State and district-to-district within States. A national need is being handled as 16,000 local problems.

A primary role of the Federal Government can be to provide a vision for teachers, encouraging them to look beyond today's classroom computer activities, small but exciting though the changes may be, and to scan the horizon for tomorrow's potential. If technology can offer opportunities for fundamental changes in how children learn, in how schooling is organized, and how teachers function, it is important that this vision be elucidated, not only by the hardware manufacturers in double page advertisements in popular magazines or on commercials during the Super Bowl, but by the Federal Government, including the Secretary of Education,