# The Promise of Technology for Teachers 2

## SUMMARY OF KEY FINDINGS

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

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

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

## INTRODUCTION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

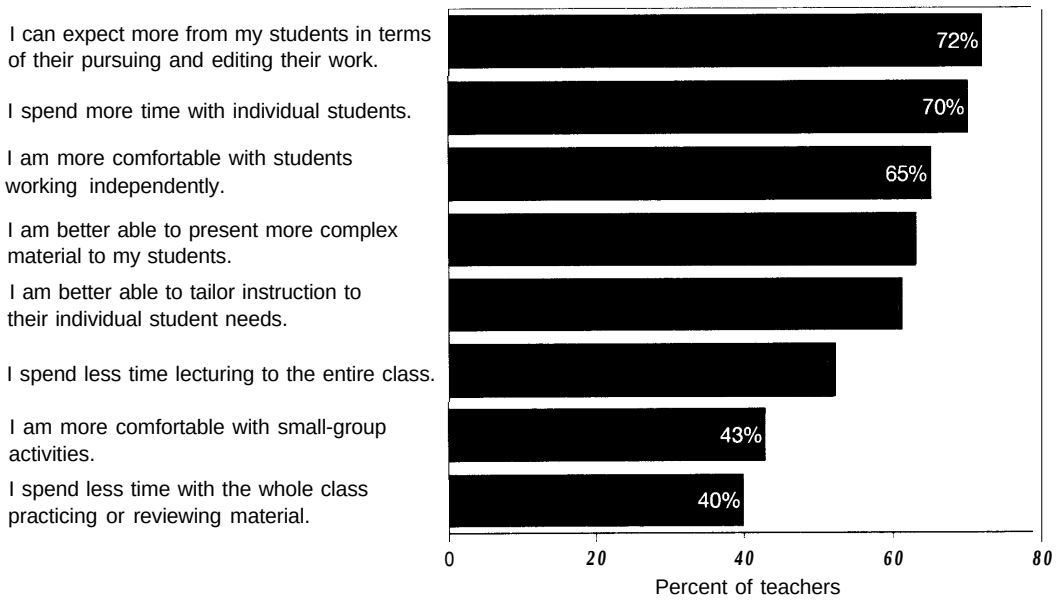
[3] Ibid , p. 15.

[4] Ibid.

[5] Ibid., p. 20

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

### Accomplished Computer-Using Teachers: How Their Teaching Has Changed




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

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

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

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

teachers to use these resources in innovative ways. The existence of these conditions is far from commonplace, as chapters 3 and 4 explain in more detail.[9] Chapter 5 discusses whether new teachers are being prepared to enter classrooms ready to use the technologies at hand. It should be stressed that the accomplished teachers whose experience is described in this chapter probably make up only a small percentage of all U.S. teachers.

## TECHNOLOGY AND THE JOB OF THE TEACHER

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

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

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

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

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

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

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

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

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

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

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

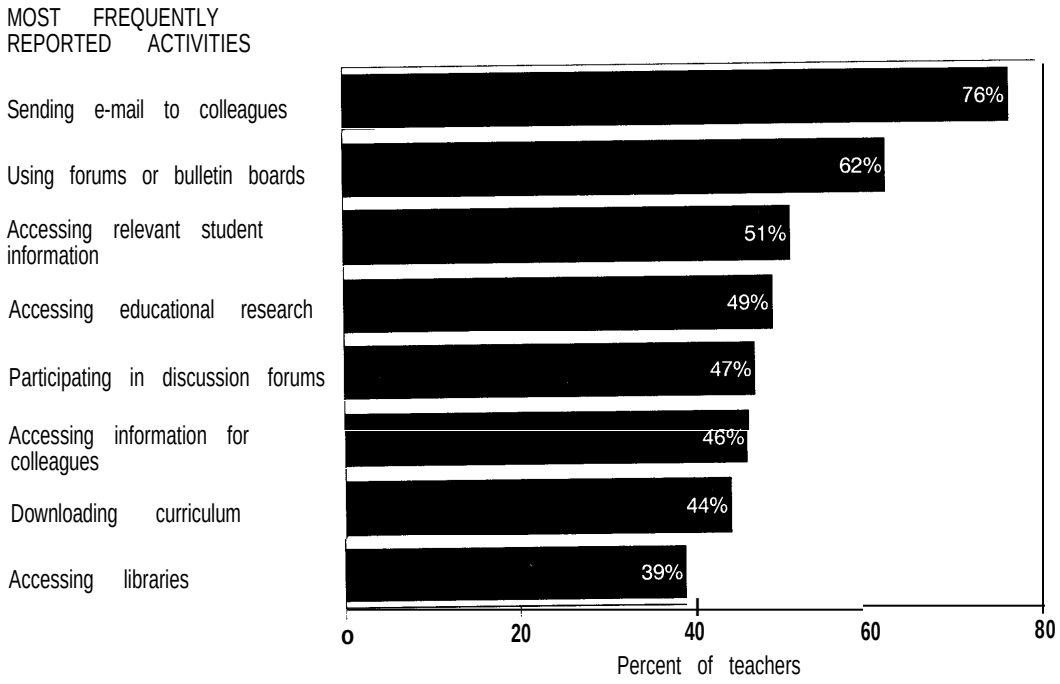
Teachers were also surveyed about the most frequent uses of telecommunications for student learning, which were less regular than teacher professional uses. The most frequently cited activities involved students' accessing services and databases, Including encyclopedias (57 percent of teachers used them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

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

*(continued)*

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

How Teachers Use Telecommunications for Professional Activities




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

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

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

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

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

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

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


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

## USING TECHNOLOGY TO ENHANCE INSTRUCTION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## ■ Bringing New Resources ' into the Classroom

As technologies have become more widely available, they have made it increasingly easy for teachers to access a broader range of materials they can use in the classroom. At the most basic level the copying machine has allowed teachers to make copies of articles, charts, or instructional materials from outside sources and share them directly with students. Supplementary computer tools—such as scanners or digitizing cameras—allow teachers to bring in outside sources, enter them into a computer, and customize assignments for students. For example, a teacher can bring a timely article from the morning newspaper into class, scan it into the computer in minutes, and have her students work on rewriting, editing, or adding research to the story on the same day. Students can browse interactively or conduct electronic research searches in CD-ROM databases, encyclopedias, or other reference works. Thus, not only do technologies allow access to a broader range of instructional resources, but they also offer students the opportunity to learn to use electronic tools to access information and develop research skills using the technologies they will face in the future.

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

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

Many of the teachers who access telecommunications networks do so after school or at night,

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

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

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

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

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

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

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

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

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

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

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

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


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

## ■ Developing New Forms of Instruction

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A Texas teacher admitted:

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

*(continued)*

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

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

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

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

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

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

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

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

[24] Linda Spoales, social studies resource teacher, Montgomery County, MD, OTA site visit Dec. 14, 1993.
[25] The "MacPaC" workstations each include a Macintosh LC Computer, a CD-ROM drive, a level III videodisc player, and a passive-matrix LCD display panel (for overhead projection of the computer screen). Each department also has a 3 I -inch television.

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

## ■ Motivating Learners

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


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

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

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

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

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

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


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

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

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

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

## ■ Individualizing Student Learning

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

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

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

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

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

## BOX 2-5: "Dear President Hoover"

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## ■ Redefining Teachers' Roles

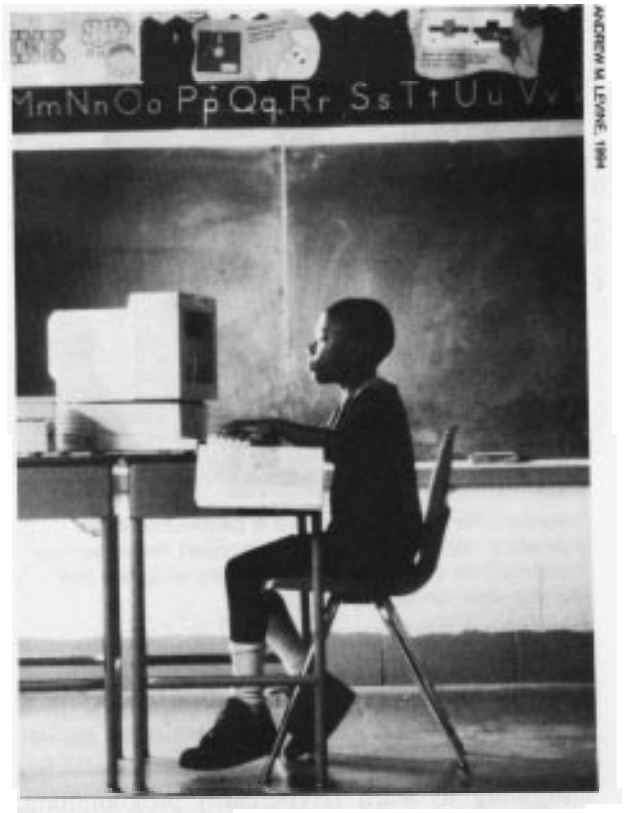
When technology is integrated into the curriculum in a comprehensive way, and when teachers feel comfortable and confident about using it, **myriad changes occur that may ultimately redefine the roles of teachers. One** teacher echoed the opinion of many when she said: "I've gone from being the 'sage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

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

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

Teachers at the Open Charter School in Los Angeles found that their roles were shifting as technology integration took over the school. The Open Charter School received enough technology to make available one computer for every two students. One teacher described the change she has gone through as she has grown more comfortable in using technology:

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




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

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

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

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


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

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

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

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

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

[44] Ibid.

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

[46] Ibid.

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

## ASSISTING TEACHERS WITH THE DAILY TASKS OF TEACHING

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

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

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

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

### Keeping Records

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

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

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

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

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

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

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

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

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

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

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

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


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

## ■ Assessing Student Learning

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

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

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

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

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

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

## BOX 2-7: Technology Tools for Teacher Productivity

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


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

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

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

[1] Software was developed and marketed by American Management Systems, Inc., Fairfax, VA, Tycho software runs on a variety of Windows-based mobile computing platforms; teachers in Florida tested Tycho on a Fujitsu hand-held pen-based device,
[2] *The Heller Report,* December 1994, p. 4,

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

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

[52] Ibid.

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

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

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

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

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

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

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

## Preparing Curricular Materials

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

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

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

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


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

might go to the school media center, review the teacher's guide and table of contents in a product like the "Windows on Science" videodisc?[55] and enter the code numbers for a particular segment she is teaching (e.g., how animals adapt to their environment). She can review the segment, choose parts she wants, and use a barcode scanner to capture that sequence and play it back in the classroom. Teachers at the Open Charter School in Los Angeles, for example, use computer-controlled videodiscs for customized presentations to students. They preselect film clips or images they want to show and stop the presentation at any point for discussion. As one teacher said, "I can talk to kids and tell them about things-like the capability of sea stars to flip over—but now I can show them. I don't need to watch an entire film to get to the part I want to see. And the students can go back and watch it over and over."[56]

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

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

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

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

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

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

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

## Improving Communication

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

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

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

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

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

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

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

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

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

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


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

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

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

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

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

65 OTA site visit March 1994.

66 Becker, op. cit., footnote 61.

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

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

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

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

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

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

## FOSTERING TEACHER PROFESSIONAL GROWTH

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

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[69] Ibid., p. 27.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[7] Ibid

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

*(continued)*

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

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

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

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

SOURCE Office of Technology Assessment, 1995

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

## Expanding Opportunities for Formal Continuing Education

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

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

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

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

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

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

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

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

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

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

[76] Ibid.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[6] Ibid.

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

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

## Fostering Collegial Work with Other Professionals

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## BOX 2-10: Teacher Collegial Exchange Using Telecommunications

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

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

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

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

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

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

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

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


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

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

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

## CONCLUSION

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

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

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

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

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