DOCUMENT RESUME

ED 355 930 IR 016 026

AUTHOR	Jordan, William R.; Follman, Joseph M., Ed.
TITLE	Using Technology To Improve Teaching and Learning. Hot Topics: Usable Research.
INSTITUTION	British Columbia Ministry of Attorney-General, Victoria.; SERVE: SouthEastern Regional Vision for Education.
SPONS AGENCY	National Science Foundation, Washington, D.C.; Office of Educational Research and Improvement (ED), Washingt.n, DC.
PUB DATE	Jan 93
CONTRACT	RP91002010
NOTE	83p.
AVAILABLE FROM	NEFEC/SERVE, Route 1, Box 8500, 3841 Reid Street, Palatka, FL 32177 ($7 each for 1-49 copies; $6 each for 50-99 copies; $5 each for 100 copies or more).
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052) -- Information Analyses (070) -- Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	*Computer Assisted Instruction; *Curriculum Development; Educational Innovation; Educational Policy; *Educational Technology; Elementary Secondary Education; Expenditures; Higher Education; *Instructional Improvement; *Learning Activities; School Restructuring; Staff Development; Teacher Attitudes; Teacher Education; *Teacher Role
IDENTIFIERS	Learning Environments; *United States (Southeast)

ABSTRACT

Computers have become one of the expected trappings of today's classroom, and schools have exhibited an insatiable appetite for hardware; but systemic curricular integration of computers is still more of a promise than a reality. Resources have been allocated and spent, but many students and educators remain technologically illiterate. Section 1 of this report discusses the need to restructure learning environments to support the active use of technology by teachers. Section 2 examines attitudes and roles that evolve among successful technology-using teachers, as well as the education and staff development they require. In section 3, the need to develop technology-based activities that engage the student in the production, rather than the reproduction, of knowledge is discussed. Section 4 gives examples of specific student activities. Any expenditure for technology must be leveraged with a greater investment in teacher training, both inservice and preservice. Throughout the document, sidebars entitled "Dynamite Ideas" offer examples of teachers, schools, and districts in the Southeast that have used technological ideas successfully. Appendixes include the policy statement of the Council of Chief State School Officers on learning technologies and the Florida Model School Consortia Act of 1985. An order form for requesting copies of SERVE publications is included. (Contains 71 references.) (SLD)

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USING TECHNOLOGY TO IMPROVE TEACHING AND LEARNING

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HOT TOPICS:
Usable Research

USING TECHNOLOGY TO IMPROVE TEACHING AND LEARNING

by William R. Jordan
Florida Computer Teacher of the Year, 1990
with Joseph M. Follman

January 1993

Produced by

SERVE
SouthEastern Regional Vision for Education

in collaboration with the

Discover
SCIENCE EDUCATION
IN FLORIDA
Office of Science Education Improvement

This publication was produced with funds from the Office of Educational Research and Improvement, U.S. Department of Education, under contract #RP91002010, and funds from the National Science Foundation Statewide Systemic Initiative Grant in partnership with Florida's Department of Education.

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TABLE OF CONTENTS

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SERVE, the SouthEastern Regional Vision for Education, is a coalition of educators, business leaders, governors, and policymakers seeking comprehensive and lasting improvement in education in Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina. The name SERVE reflects a commitment to creating a shared vision for the future of education in the Southeast.

The mission of SERVE is to operate as an education laboratory that provides leadership, support, and research to assist state and local efforts in improving educational outcomes, especially for at-risk and rural students.

Laboratory goals are to

- address critical issues in the region,
- work as a catalyst for positive change,
- serve as a broker of exemplary research and practice, and
- become an invaluable source of information for individuals working to promote systemic educational improvement.

To focus the work of the laboratory and maximize its impact, SERVE emphasizes one of the national goals established by the President and National Governors' Association for regional attention each year. A special ongoing project, SERVEing Young Children, examines ways to ensure that all children are ready to begin school.

SERVE offers a series of publications entitled ***Hot Topics: Usable Research***. These research-based publications address issues of present relevance and importance in education in the region and are practical guidebooks for educators. Each is developed with input from experts in the field, focuses on a well-defined subject, and offers useful information, resources, descriptions of exemplary programs, and a list of contacts.

Several *Hot Topics* are developed by SERVE each year. The following *Hot Topics* are presently available:

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Collaboration and networking are at the heart of SERVE's mission; the laboratory's structure is itself a model of collaboration. SERVE has four offices in the region to better serve the needs of state and local education stakeholders. The contract management and research and development office is located at the School of Education, University of North Carolina at Greensboro. The laboratory's information office, affiliated with the Florida Department of Education, is located in Tallahassee. Field service offices are located in Atlanta, Greensboro, Tallahassee, and on the campus of Delta State University in Cleveland, Mississippi. Addresses are provided below.

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Knowing how our products are used is very important to us at SERVE. Your feedback on this publication will permit us to better assist you, and your recommendations will be incorporated into future editions. Please help us by providing a brief response to the following:

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SERVE would like to highlight outstanding school technology programs with which you are involved or familiar. These programs will be publicized in future editions of this and other *Hot Topics* and considered for recognition in the SERVE Sharing Success program. Please let us know what you are doing!

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INTRODUCTION

In times of change, learners inherit the earth, while the learned find themselves beautifully equipped to deal with a world that no longer exists.
Eric Hoffer

To the extent that tools and resources define a society, we have clearly moved from the Industrial Age to the Information Age. Computers have become a tool of choice and information has become a valuable resource. Technology, the catalyst for this transition, is affecting every facet of society that deals with the generation, storage, or transmission of information. Technology increasingly affects our work, politics, and entertainment. Ironically, computers and associated technologies have had only a limited impact on society's most information-rich institution: education.

Nationwide during the 1980s, the number of microcomputers and computer terminals in U.S. schools grew from fewer than 50,000 to roughly 2,400,000—an almost 50-fold increase (Becker, 1990b). But while computers have become one of the expected trappings of today's classroom and schools have exhibited an insatiable appetite for hardware, systemic curricular integration of computers is still more promise than reality. In many cases, computers are used to support traditional goals, using established methods, in class settings which have changed little since the dawn of the Information Age. Possession does not guarantee productive use; many computers sit idle, shrouded in dust covers, because implementation guidelines, software purchases, and technology training for teachers have not kept pace with hardware acquisition. The result is that although resources have been allocated and spent on classroom computers, too many students and educators remain technologically illiterate. Less than a decade after designating the computer as "Man of the Year," *Time* magazine characterized computer-assisted instruction as "the revolution that fizzled" (Elmer-Dewitt, 1991).

While many teachers *are* using technology, because of unmet training or support needs, they tend to implement a program of instruction not much different from the curriculum they would have followed without computers (Becker, 1991). Unless exposed to better alternatives, teachers tend to resist altering their attitudes and teaching strategies. The good news is that some teachers *have* successfully incorporated computers and other technologies into their curriculum; using their training and knowledge, these teachers and their students use computers to conduct experiments, plan activities, and communicate across continents.

Technology can fill the gap between the promise and the reality of educational computing, but it will take motivated, innovative, and informed teachers to bridge it. The efforts of the successful technology-using teachers are the focus of this document. To meet educational challenges of the 21st century, we must, as Thornburg (1991) declares, "think in the future and act in the present" (p. 111).

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The future demands individuals who are technologically literate, but they must also be critical thinkers, adept problem-solvers, able to access and organize information, capable of cooperative decision making, and prepared to be life-long learners. If schools are to prepare students for the future work place, then schools must in some ways resemble that workplace and technology is an important ingredient (D'Ignazio, 1990). Re-focusing our vision for implementing educational computing requires us to address the following question:

> *How can teachers use computers and related technologies to create learning environments that actively engage students in meaningful instructional activities?*

This *Hot Topic* looks for answers and provides educators with useful information, resources, and sample activities which they can put into action in their schools. There are four sections:

Section One discusses the need to restructure learning environments to support teachers' active use of technology.

Section Two examines attitudes and roles that evolve among successful technology-using teachers as well as the education and staff development they require.

Section Three discusses the need to develop technology-based activities that engage students in the *production,* rather than the *reproduction,* of knowledge.

Section Four gives examples of specific student activities.

Throughout the document, many "Dynamite Ideas" offer examples of teachers, schools, and school districts in the Southeast that have embraced educational technology with great success. Technology has become an inseparable part of our work and leisure; it is only common sense that it must also be an integral part of every child's education.

(Note: The mention of specific brands of computers or software does not represent an endorsement of those products by SERVE.)

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ACKNOWLEDGMENTS

Hot Topics: Using Technology to Improve Teaching and Learning was developed with the assistance of a Regional Review Panel of state-level experts in instructional technology, mathematics, and science education. Information and resources provided by review panelists greatly enhanced the final product.

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Section 1

Restructuring Learning Environments

Why Restructure Learning Environments?

- What happens when schools try to change?
- Are teachers prepared to integrate technology into their instruction?
- Why are some teachers anxious about computers?
- How effective has computer-based instruction been?

What is the Role of Technology in School Restructuring?

- What are the institutional obstacles to change and how can they be addressed?
- What is a teacher workstation and what capabilities should it have?
- How can telecommunications benefit teachers?
- How might a new learning environment look?

RESTRUCTURING LEARNING ENVIRONMENTS

There are no limits to educational technology; there are only limits to school organization that limits its uses. As long as schools are organized like factories of the late 19th and early 20th centuries, educational technology will only be a flickering hope.

D.P. Doyle
Endangered Species: Children of Promise, 1989

Restructuring implies a new notion of schooling based on the recognition that conventional ideas no longer work.

T. Kolderie
How Structured Change Can Speed the Introduction of Technology, 1990

WHY RESTRUCTURE LEARNING ENVIRONMENTS?

The school-as-factory model worked well in the Industrial Age: students were the products, the curriculum was the assembly line, and teachers were the workers. Society's institutions were more stable, and the tools of the workplace were familiar and easily mastered. The traditional roles of teachers were perpetuated by the accepted organizational structure of schools. However, rapidly changing world events, evolving social institutions, and new workplace demands raise questions about whether our educational system is responsive to the needs of the Information Age. As with military planners who are often said to be preparing to fight wars of the past instead of the future, many school reformers seem to be trying to "fix" schools based on ideas from an earlier era. In light of the educational needs of the 21st century, these efforts have not been successful.

Mounting evidence and a growing consensus of opinion suggest that America's public school system must change in order to function in society both today and tomorrow. Many believe that our educational system is so outdated that *revolutionary*, not evolutionary reforms are needed to address required changes (Newman, 1991). The needs of the Information Age are radically different from those of the Industrial Age model of education, and anything short of *restructuring* the entire system will fail short.

Although it is defined in more than one way, restructuring is characterized by a growing consensus as "not just doing business as usual, not just fine-tuning, but changing things so that students really learn and teachers really find satisfaction and rewards in practicing their profession" (Barron and Bergen, 1992, p. 521). Restructuring implies a new notion of schooling based on the recognition that conventional ideas no longer work (Kolderie, 1990).

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DYNAMITE IDEAS:

MULTIMEDIA AS INSTRUCTIONAL TOOL

Carrollton City Schools, just outside of Atlanta, Georgia, use technology as the vehicle to restructure for better learning and student achievement. Corporate grants, bond referenda, and district investment have allowed the district, and Carrollton High School in particular, to integrate technology into the school curriculum.

Known as a "High School of the 21st Century," Carrollton High has over 300 computers--an average of seven in a cluster per classroom--which are linked via token ring and eight file servers. Students can take classes in Japanese and Russian through a link-up with the Universities of Nebraska and South Carolina. The school is a pilot site for implementation of an interactive multimedia product which contains 180 hours of interactive learning delivered through classic literary works by Shakespeare, Tennyson, and others.

Students can digitize and customize video images from CD-ROM, video cameras, videodiscs, VHS tape, and live television. They create multimedia reports, projects, and videotape "books." Sharing the computers encourages students to work cooperatively. In-class computers linked with the local cable company allow students to see national and international news, business reports, and sports events.

The district has received nearly $1 million from IBM Corporation and hopes to expand its program to middle school students. In addition to purchasing equipment, funds will be used to provide more individualized instruction and improve feedback and reporting to parents.

Contact:
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Carrollton, GA 30117
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What Happens When Schools Try to Change?

Human beings are naturally resistant to change and fearful of things perceived as different and complicated; schools and educators are no different. Students, teachers, administrators, classrooms, schools, and curricula are discrete yet integrated parts of an educational system that has developed and solidified over more than a century. Like a thermostat, these parts are inclined to seek equilibrium. Similarly, attempts to introduce computer technology into the curriculum—a change in function—are usually sustained only to the degree that the prevailing institutional structure is maintained (Collins, 1991). Therefore, changes must be systemic because a school's form and function are symbiotic: they can be distinguished but not separated. As noted by Ray (1991b), any substantial change in the function of schools (e.g., curriculum, instruction, methodologies, etc.) will require corresponding changes in the schools' organizational structures.

Are Teachers Prepared to Integrate Technology Into Their Instruction?

Too many teachers are not prepared to teach with computers. Studies have shown that

- most teachers consider themselves less computer literate than their students (Wirthlin Group, 1989);
- most new graduates from teacher-training institutions are unprepared to enhance their lessons with technology (Ward, 1990);
- fifty-nine percent of all U.S. teachers believe they are inadequately trained to use computers in the classroom (Wirthlin Group, 1989);
- only about one-third of all K-12 teachers have had more than ten hours of computer training (Office of Technology and Assessment, 1988); and
- the amount of training and practice time required to make a novice computer-using teacher feel capable of thinking about curriculum change is estimated to be approximately 1,000 hours (Roberts et al., 1988).

Not surprisingly, teachers continue to have mixed feelings about educational technology. These feelings range from uncertainty to acceptance, ambivalence to enthusiasm.

Why are Some Teachers Anxious About Computers?
Many teachers label themselves "B.C." (before computers) and may be "technophobic" or otherwise resistant to using computers in their classrooms. At least three reasons are commonly identified for computer anxiety among teachers (Office of Technology and Assessment, 1988, p. 98):

1. Teachers, trained to master the traditional tools and materials of their profession, fear their lack of expertise with computers will be embarrassing and undermine their classroom authority.
2. Some teachers may be uncomfortable with the ways that classroom roles and relationships between teacher and student change when computers are introduced into the classroom.
3. Teacher productivity and student success can be monitored with computers easily, but many teachers worry about accountability since the problem-solving skills they try to teach may not be measurable through assessment instruments they have been using.

The persistent myth that computers can replace teachers is likely an additional concern. In reality, teachers are the key to the success of educational computing. While computers are tireless, non-judgmental instructors, no machine can replace the human contact and interaction that students will always require.

No matter what its basis, however, computer anxiety frequently affects user motivation and ability to master computer skills (Loyd and Gressard, 1984; Wood and Barnes, 1991). Computer anxiety must be addressed in order to change teachers' attitudes about the use of technology.

"Well, today we learned to reorder segments on a random-access videodisc through the process of microcomputer interfacing."

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Statistically valid research on the effectiveness of educational computing is limited, and findings have often been ambiguous or contradictory.

How Effective has Computer-Based Instruction Been?

Research on instructional computing teems with references to the Microcomputer Revolution, implying that a fundamental change in education is taking place due to the use of computers. For a variety of reasons, however, impacts (e.g., student achievement, attitudes toward learning, dropout rates, and learning time) have not been validated or measured thoroughly. Statistically valid research on the effectiveness of educational computing is limited, and findings have often been ambiguous or contradictory. Yet there is some evidence of the benefits of computer-based instruction. In an instructive study on this subject, Roblyer et al. (1988) reached the following general conclusions about outcomes:

- Computer applications (i.e., drill and practice, tutorials, and simulations) were equally successful among students regardless of ability level.
- Computer applications were equally effective with males and females.
- Highest results were obtained at college/adult levels. Effects from elementary levels were slightly higher than for secondary. (Earlier analyses noted greatest effects at the elementary level.)
- Attitudes toward school and subject matter were positively affected by computer use.
- Computer applications in math, reading, and cognitive skill areas all showed similar positive effects, while the effects in science were nearly twice as great. (Previous analyses found the highest results to be in mathematics.)
- All types of applications of computers for mathematics were about equally effective.
- In teaching reading, tutorial applications showed greater effects than other types of software.
- The high positive effects in science all occurred with simulations used in unstructured settings.

(Ellis, 1990, p. 23)

A 1989 survey of elementary and secondary teachers indicated that teachers who use computers find they improve the learning process in their classrooms. Of the teachers surveyed,

- sixty-four percent said computer use helped reduce dropout rates of at-risk students,
- eighty-two percent indicated the use of computer-based reading and writing programs in the early grades helped improve literacy,
- ninety-one percent said computers were effective tools to

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help students develop basic reading and writing skills (*although 60 percent said they were not used that way*),

- approximately eighty-five percent said computers increased motivation, helped students with problem solving, boosted student self-confidence, and helped unlock creativity,
- ninety percent stated a lack of computer access was a special learning disadvantage for students from less affluent schools,
- sixty-two percent agreed computers could help reduce classroom discipline problems,
- seventy percent said software which incorporated the high-tech culture of today's students could make it easier to reach them with messages about alcohol, drugs, and sexuality, and
- sixty-three percent stated computers in the classroom could stimulate greater parental involvement.
  (Becker, 1990b)

While research on educational computing is new, cannot yet be based on longitudinal studies, and has frequently lacked rigorous methodology, these findings are quite encouraging. It seems apparent that there is enthusiasm about the potential of instructional technology.

WHAT IS THE ROLE OF TECHNOLOGY IN SCHOOL RESTRUCTURING?

Schools are just beginning to explore the role of technology in restructuring. Pilot programs such as ACOT (Apple Classroom Of Tomorrow), Project CHILD (Computers Helping Instruction and Learning Development), the Saturn Schools of Tomorrow, and various model technology school programs are finding solutions based on practical experience. They are, as noted by Ray (1991b),

> slowly trying to move from a model of school-as-machine, congruent with a mechanistic, industrial organization paradigm, to a model more like school [as] an organic information processing system that is multidimensional and flexible (p. 8).

Today's technology offers powerful tools for transforming what we do, what our organizations look like, and even how we think about the world.

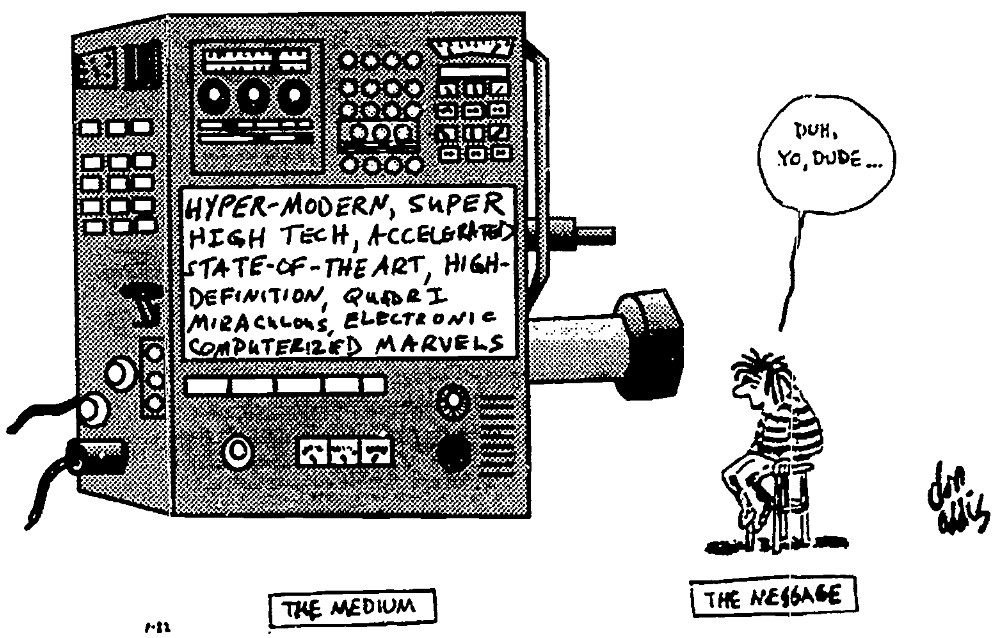
J.L. David
Restructuring and Technology. Partners in Change, 1991

What are the Institutional Obstacles to Change and How can they be Addressed?

State, district, and/or school rules and regulations have always been major obstacles to change in education. Loosening bureaucratic policies and regulations permits greater flexibility. Policymakers must be willing to examine and discard habits, beliefs, and ingrained institutional policies that deter reform.

Schools do not exist in a vacuum; they are governed by many forces. Implementing systemic change requires that everyone (i.e., teachers, administrators, parents, school boards, unions, legislatures, and state and federal agencies) be brought "on-board" with common goals. In the present climate of restructuring, many districts and states are re-examining their regulations and requirements and providing waivers of policies that impede reform.

Several common denominators which have been identified as impediments to restructuring and the effective use of technology, as well as some suggested solutions, are described in the chart on the following pages (Butzin, 1990; Butzin et al., 1991; Dwyer et al., 1991; King, 1992).



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IMPLEMENTING CHANGE: OBSTACLES AND SOLUTIONS

Obstacle	Solution
Schools are often slaves to their schedules. The master schedule—times for planning periods, busses, lunch, activity periods, bells, recess, etc.—are seen by some school personnel as immutable.	Increase flexibility by allowing demand, need, and opportunity to dictate schedules, instead of the reverse.
Aspects of using technology can complicate teaching. Technology-based work is time-consuming for students as well.	Schedule extra planning time for teachers to learn how to use the technology as well as to prepare to use it with their students. In addition, adjust student schedules so students have larger blocks of time, access to computer labs, or opportunities to collaborate with other teachers to complete their work. Once they are familiar with technology, teachers and staff can use it to complete many tasks more quickly.
Schools are built on a template. Most rooms look alike, are the same size, and are equipped with standard features. Computers and related technologies require rooms that accommodate both equipment and people.	Restructure learning environments by designing non-traditional classroom configurations and using technology imaginatively. In one common model, overhead display panels, projectors and screens are used for computer-based demonstrations in one-computer classrooms. Other examples include classrooms or studios designed especially for technology-intensive projects or for the public display of student work. Learning centers can also facilitate computer work as well as the development of listening, viewing, writing, and manipulating skills.
Classrooms are not wired to handle the electrical requirements of computers, which need "clean" power, free from electrical noise and surges. Computer labs, file servers, and workstations require uninterruptable power supplies to guard against equipment damage and loss of data.	Build classrooms with sufficient outlets to operate a variety of technologies safely. In existing schools, dedicate a room as the command center or power station for the entire school.
Teachers do not have sufficient access to computer technology.	Increase access in order to develop teacher proficiency and increase professional productivity. Place a computer workstation on every teacher's desk, and equip workrooms with adequate hardware and software. Make loaner machines available for teachers to use at home.

Obstacle	Solution
The typical classroom teacher is unable to keep abreast of advances in technology.	Schools can develop teams of resident experts, each of whom is knowledgeable of a particular piece of hardware or software and who can facilitate its use by others. (See "Dynamite Idea" on pages 30-31.)
Teachers do not receive enough preservice, inservice, or follow-up training.	Create a position for a technology resource teacher to help others learn to use the equipment and integrate it into instruction.
Addition of technology can add to bureaucracy and paperwork.	Use technology to automate many routine requirements and *reduce* paperwork. Classrooms can be connected by local area networks (LANs) so that administrators and teachers can transfer bulletins; send mail; request supplies; and record schedule changes, attendance data, and textbook orders.
Restructured learning environments and technology suggest the need for entirely new courses and instructional techniques.	Use multi-age grouping to allow classes at different grade levels to remain with the same teacher for several years, allow teachers to develop closer rapport with students, and design better individual instruction based on long-term awareness of students' developmental progress. In addition, older students can help younger students become proficient with the use of technology, freeing the teacher to concentrate on instructional tasks. Interdisciplinary courses and projects designed around themes create a seamless curriculum that enables students and teachers to see how different subjects are interrelated.
The more detailed and creative work students will do cannot be adequately measured by traditional assessment methods such as multiple-choice tests.	Use alternative assessment methods such as outcome-based measures. For example, use portfolios showing progressive application of skills and subject area content.

The ingredients for change are present. Restructuring provides the context for the kinds of changes needed. Technology supplies the catalyst to help implement the changes. Imagination and creativity are called for, because as Thornburg (1991) reminds us, "The hardest step to educational reform seems to be the part that costs nothing—vision" (p. 29).

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Technology alone cannot restructure schools, but neither can schools successfully restructure without incorporating the technologies that have become the basic tools of business, industry, and communications. According to Ray (1992), "the wise use of technology is fundamental to the restructuring of schools if only because it has been fundamental in restructuring the society schools seek to serve" (p. 9). Both initiatives must be pursued concurrently in order to alter the structure and function of schools; however, such reforms cannot neglect the reality that schools are social organizations and teachers remain the key to success in any educational change.

As the "classroom gatekeepers" (Cuban, 1986), teachers must not only support change; they must also be given the tools to implement it. Two of these essential tools are teacher workstations and access to telecommunications; both can serve as initial, concrete steps toward restructuring.

What Is a Teacher Workstation and What Capabilities Should It Have?

A teacher workstation is a combination of hardware and software that may on the surface resemble a common desktop personal computer, but is designed specifically to help teachers teach; it is not a modified industrial workstation. A teacher workstation is designed to accommodate the specific administrative and instructional needs of educators and has a variety of capabilities.

The following features were given highest priority in a recent survey of 700 teachers (Forrester, 1992). A teacher workstation should

- facilitate oral, written, and electronic communication among teachers and between the teacher and students, parents, administrators, and district staff;
- help teachers design and produce professional-looking materials such as handouts, transparencies, tests, worksheets, and newsletters;
- enable teachers to create multimedia presentations that include audio and video components;
- provide individualized instruction for students with specific areas of need as well as enrichment activities to meet challenges beyond the basics; and
- allow accomplishment of administrative tasks such as managing student records, attendance, grades, and curriculum information.

The hardware or "platform" required to provide these capabilities must have adequate processing power, storage capacity, and video resolution.

DYNAMITE IDEAS:

SERVE-LINE

SERVE-Line, sponsored by SERVE, is a computer network and electronic bulletin board which allows users to access and request information and current publications and communicate with others nationwide. Through the use of a computer, modem, and telephone line, any interested person can call, toll-free, and send or receive information. Access is available 24 hours daily.

The main SERVE-Line menu lists services available at no charge and includes a calendar of events; "Education in the News"—a monthly column of news clippings about education from around the region; an annotated list of education-related publications and products; an information request service; and a "What's Your Opinion?" category.

Service for subscribers include an information exchange; essays on top educational issues; a "Faculty Lounge" where users can share ideas with others ("ShareWare Closet" contains public domain computer programs and software for both IBM and Macintosh users and includes lesson plans, teaching guides, grading book and attendance report systems, tutorials, and learning games and activities for students.); *R&D Preview*, produced monthly by the Council for Educational Development and Research, with articles, news stories, commentaries, and annotated bibliographies on education-related research and development projects around the nation; and an electronic mailbox.

One-year subscriptions are $25 for individuals, school buildings, district offices, and college/university departments, and $250 for businesses, agencies, and consultants. For more information, call (800) 659-3204 or (404)-577-7737 (Atlanta). To access SERVE-Line electronically, dial (800) 487-7605 or 577-7641 (Atlanta). Or write Mark Wayne-Hart, SERVE, 41 Marietta Street, N.W., Suite 1000, Atlanta, GA 30303.

DYNAMITE IDEAS:

LEARNING CIRCLE

Ridgecrest Elementary School in Huntsville, Alabama has joined schools throughout the U.S., Canada, and Bermuda to form the Learning Circle, an innovative telecommunications project. Through this project, fifth graders collaborate with students at eight other schools in studying a common curriculum, "People and Perspectives." Sponsored by AT&T, the purpose of the Learning Circle is to develop the technological and higher-order thinking skills required for successful living in a global society.

These skills are integrated in all phases of program operation. Communication between sites is conducted via computer and modem. The class learns how to operate the modem and connect a telephone to the computer to conduct telephone research surveys. Once the surveys are conducted, students analyze and chart or graph the data they have collected.

Students apply skills in geography when identifying locations on maps and practice writing skills when recording research in their journals. Telecommunications terms become spelling words. The students also produce a videotape of their projects and the *Journal of Places and Perspectives*, a publication which contains their research material depicting a micro-global society. Participating students have shown improved levels of achievement and self-esteem.

The surveys conducted through the project also foster global awareness by revealing differences and similarities among people. For example, the students learned that pizza was the favorite food of their peers from Hawaii to Bermuda to Alabama to Canada.

continued . . .

Whatever platform is chosen, the recommended workstation should have a 32 bit CPU (e.g., 486DX, 586DX, or M68030) 4-8 MB of RAM (operating memory), a 100+ MB hard disk (for strong data and programs), and a high-resolution monitor. A high-quality printer, preferably of laser quality, should also be available.

Beyond this nucleus, the recommended workstation is modular, expandable, and adaptable. Modularity allows the addition of various peripheral devices as needed (e.g., CD-ROM, videodisc player, LCD panel, large screen projection device). Expandability means that extra slots are available for memory upgrades and additional interface boards, such as for video capture and playback. Adaptability comes from use of specific software that will allow teachers to adapt and customize the system to their individual needs regarding grade level, subject matter, and program area. Before investing in a hardware platform and configuring it with peripheral devices, decisionmakers need to ensure that teachers—the end users—participate in the design and selection of their workstations.

How Can Telecommunications Benefit Teachers?

Once teachers are equipped with a suitable hardware platform and the basic software required to apply the computer to the classroom environment, they can then take this technology one step further: telecommunications.

Despite working in a building full of their peers, teachers are often isolated by the present classroom structure. In addition, normal communication channels in schools (e.g., the intercom, meetings, and messages) may not supply teacher with accurate and timely information in a non-disruptive manner. Message boxes are often sources of information overload, and faculty and department meetings can be dominated by information and policy dissemination to the detriment of curricular and professional matters. Teachers need more immediate, two-way communication to expand their (and their students') horizons.

A teacher workstation equipped for telecommunications can address many of these needs. Voice communication and in-school LANs (Local Area Networks) can connect users within a single physical plant, while remote networks and bulletin boards can put teachers in touch with professionals across the region and around the world.

Using a modem, which allows computer telecommunications over regular telephone lines, a school can reach beyond its physical boundaries to access information and resources not available locally. What once seemed to exceed the resources and realm of the traditional classroom is now educationally and economically feasible. In addition, the same system that allows a teacher to communicate with someone on another continent can also improve communication with the teacher next door through a local area network.

Telecommunications overcomes two communication barriers: distance and time. Ideas and information do not have to wait for individuals to get together. Telecommunications dissolves these barriers by offering increased access to people, information, and learning opportunities. Electronic mail (E-mail) allows individuals to send and receive letters, messages, and other types of files rapidly and conveniently. Database services permit on-line information search and retrieval. Electronic conferences permit many participants to discuss issues in real time or respond at their leisure.

Electronic bulletin boards offer access to special interest forums and the opportunity to obtain ("download") useful programs and files. Other telecommunications possibilities include access to

- experts, for both staff and students;
- rapid sharing of information or data;
- other students, teachers, and classrooms at the local, state, national and international level;
- large information databases not available locally;

and exposure to

- an audience for student products;
- training and tutoring for staff and students;
- innovative approaches to make curriculum come to life;
- an opportunity to broaden staff and student perspectives, including an understanding of other cultures; and
- greater opportunities for collaboration and cooperative learning

(Ambler and Jacobs, 1991; Potter and Davis, 1991)

Each of these possibilities provides opportunities that empower teachers and students to communicate and learn. Telecommunications makes it possible to create a global classroom: a learning environment with no boundaries. Once considered a frill, telecommunications is now an essential resource in the classroom.

How Might a New Learning Environment Look?

We have to challenge the notion that our math curriculum can continue to consist of eight years of 15th century arithmetic, followed by one year of 17th century algebra, followed by one year of 3rd century B.C. geometry.

Lamar Alexander,
Former U.S. Secretary of Education

LEARNING CIRCLE continued . . .

Community support for the project has included participation in telephone surveys by local industries and contributions of materials for informational packets exchanged with other schools from the Chamber of Commerce and the Alabama Space and Rocket Center. The success of the project has led to its implementation by nine other schools during the 1991-1992 school year.

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Source: *Sharing Success in the Southeast: Math, Science, and Computer Education*, 1992

Although there is no single "correct" model, one way to visualize new images of schooling is through the following hypothetical example:

Mrs. Glass has taught seventh grade mathematics for many years. This year, some changes were made after her middle school was granted a waiver from many state and district regulations to allow novel approaches to meeting school improvement goals. Flexible scheduling was instituted. On Mondays, there are eight fifty-minute periods, but the rest of the week is different. Tuesday and Thursday, periods 1, 3, 5, and 7 meet for 75 minutes while periods 2, 4, 6, and 8 meet for 25 minutes. On Wednesday and Friday, the schedule is reversed.

The extended class times allow students to finish the detailed work which is now required of them. Each teacher is responsible for six periods of instruction, while planning time can be devoted to professional obligations and development because many parents volunteer to perform duties once assigned to teachers.

Facilities have also been reorganized. Every classroom is equipped with telephone lines, fiber optic cables, and at least one learning center with a computer. Some classrooms have been remodeled to accommodate small group work. Science labs are equipped with microcomputers at each lab station. A student computer resource room has been established in the media center, supervised by an aide hired to manage the facility.

Resources have been reallocated. Each teacher has a computer workstation with an overhead display, allowing software to be demonstrated to the whole class. Large-screen monitors are available to supplement traditional curriculum materials with selections from a wide variety of videodiscs. A LAN was installed to allow teachers to send grades and attendance information to the office, and Mrs. Glass now receives E-mail, bulletins, announcements, notices of parent conferences, minutes of faculty meetings, schedule changes, and other information electronically.

Each teacher has become proficient with at least one piece of hardware or software and helps others learn how to use it. Loaner computers are available for teachers to use at home. Students have ready access to graphing calculators, laptop computers, and video equipment. Teleconferences captured by a satellite downlink and distributed throughout the district via fiber optic cable allow teachers to obtain current technology education and recertification through distance learning.

The greatest reorganization has involved the curriculum. Mrs. Glass still teaches the basic mathematics content, but in a different context. She has sixth, seventh, and eighth graders together in classes, and her students frequently undertake interdisciplinary projects that employ cooperative learning strategies. The standard math courses have been renamed and redesigned arc ind interdisciplinary themes that explore additional issues such as employment, banking, consumer issues, and sports. Students demonstrate their understanding of the underlying mathematical concepts through projects that demonstrate authentic achievement and through other forms of alternative assessment.

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Is such a scenario realistic? While you might think it is not possible for your school or district, there are in fact schools which are already doing many or all of these things. At such schools, educators have been able to move beyond prevailing educational models which emphasize learning content and focus instead on learning how to learn. In these schools, students engage in "knowledge construction" under the guidance of educational facilitators in dynamic learning environments.

Whereas computer-based education during the first decade of the microcomputer revolution was technocentric, the growing awareness that technology also affects the classroom's social fabric is confirmed by observers who frequently notice a nontraditional climate and culture in classrooms where computers are used effectively. Different behaviors and attitudes are exhibited by students and teachers alike.

The differences between the traditional and the restructured classroom have less to do with *content* than *context*. To the uninitiated observer, a classroom rich in computer activities may seem confusing and unstructured. There *is* a different atmosphere; a different rhythm to activities when compared to many traditional classrooms. While active involvement characterizes this new classroom culture, the real difference is *interactivity*—students interacting not just with machines, but with each other and their teachers through the use of machines. The old stereotype—a roomful of computer hackers who tediously develop esoteric algorithms in high-level programming languages—has faded. A new image of computer use is emerging, in which "the best peripheral for a computer is another chair" (Madian, 1991, p. 2). The message of the new, electronic medium is clear: interactivity and cooperative learning are in; isolation and competition are out.

Schedules, facilities, resources, and the curriculum can certainly be altered to create new learning environments (i.e., restructured schools and classrooms), but changes in form and function will be of little consequence unless the teaching/learning climate and culture are also altered. Elmore (1992, p. 47-48) states that we have traditionally held school structure essentially constant, insisting that "variations among students and teaching practices accommodate the structure." He foresees that in the future, "rather than structure driving practice, teaching practice will drive structure." This vision requires establishing nothing less than a new institutional culture that permits a new social contract

DYNAMITE IDEAS:

FLORIDA'S MODEL TECHNOLOGY SCHOOLS

In 1985, the Florida Legislature passed the Florida Model School Consortia Act to strengthen the public school system by establishing prototype technology schools throughout the state. These schools experiment and conduct research on how educational technology can be most efficiently and effectively incorporated into schools. Goals of the program are to prepare students for the "rapid changes in society brought about by the infusion of technology in all aspects of life" and to encourage teachers to incorporate technology into their teaching, learning, and management functions.

Three elementary and two high schools have been designated as model technology schools. From establishing LANS, E-mail, producing school newspapers on desktop publishing, replacing typing classes with courses in word processing, making movies, and conducting chemistry experiments via computer, to having students plan cities on computers and participate in foreign language classes at out-of-town universities via distance learning, the model schools are redefining how instructional technology can be used and serving as an example for other schools in the state.

A newsletter, *Innovators & Innovations*, describes the model schools and their programs in instructional technology. See Appendix B for the Act, a list of participating schools, and additional contact information.

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DYNAMITE IDEAS:

THE HAYES COOPER CENTER FOR MATH, SCIENCE, AND TECHNOLOGY

The first and only magnet school in the Mississippi Delta, the Hayes Cooper Center in Merigold seeks to provide quality educational options for all its students by integrating computer use into every subject area. Half of the students at Hayes Cooper are black; half are white. The program seeks to eliminate statistical differences in grade-level achievement and standardized test scores between black and white students by offering every student an individualized educational program tailored to meet his or her learning style and academic needs and by providing educational experiences in which children learn by doing.

All students, even kindergartners, are taught the basics of computer programming and keyboard skills. Mathematics and science skills are reinforced by computer instruction—both individual and cooperative group instruction. Grade K-3 classrooms have learning centers equipped with five to seven computing stations where students complete work and receive remedial help in math, writing and language skills, typing, and science. Younger students also rotate to the center's laboratories for hands-on language study, media center activities, and individualized computer lessons.

Teachers in grades four through six integrate the use of in-class computer stations into subject presentations and assign students independent work time at the terminals. Students also complete individualized lessons tailored to their academic progress and remedial needs at the center's 28-station computer lab.

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between teachers and students. Teachers' roles and attitudes must change as well as the achievement we expect from students; in the next section new training goals and role expectations will be discussed in detail.

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Section 2

Expanded Roles for Technology-Using Teachers

Teaching in a Technology-Rich Environment

- What new attitudes must teachers develop?
- What expanded roles will teachers assume?
- What are the stages of instructional evolution in technology-rich classrooms?
- What are some characteristics of accomplished technology-using teachers?

Training for the Future

- What computer competencies do teachers need?
- How should preservice computer education for teachers be structured?
- How should technology inservice education be structured?
- What role do administrators have in technology education?

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EXPANDED ROLES FOR TECHNOLOGY-USING TEACHERS

While technology of all kinds has provided us with an exciting opportunity for new teaching methods and techniques, and for new ways to enhance and expand the learning experience, it is still the teacher who must make it all work.

J. L. Roberts, *The Kingpin of Education*, 1989

TEACHING IN A TECHNOLOGY-RICH ENVIRONMENT

Every teacher has a "style." This style–and the role a teacher assumes as the classroom leader–is defined by the beliefs and attitudes teachers form during pre-service education, on-the-job training, and from their own experiences as students. None of these events can adequately prepare teachers to learn and practice the new attitudes and roles required to teach in a technologically restructured learning environment. Furthermore, Cuban (1986) states that collective classroom wisdom tends to exert pressure for conformity far more than for change. Consequently, ingrained teacher attitudes may be obstacles to educational change, especially when technology is involved.

As teachers assume new roles, the emphasis of their instructional practices shifts from product to process.

What New Attitudes Must Teachers Develop?

Teachers with experience using computers report significant changes in their teaching practice. These changes include presenting more complex material, giving students more individual attention, allowing students to work more independently, and functioning more as coaches and facilitators in the classroom (Sheingold and Hadly, 1990). The following distinct shifts in attitudes and behavior have been noted as teachers become more comfortable with the use of computers in the classroom (Butzin, 1990; Butzin et al., 1991; Dwyer et al., 1991; Thomas and Knezek, 1991):

- **Teacher-Centered to Student-Centered Activities**: Teachers move from lecturing and directing ("sage on the stage") to facilitating and coaching ("guide on the side").
- **Whole-Class to Small-Group Instruction**: Teachers engage in fewer activities involving the entire class at once. Instead, they promote activities involving small groups of students working cooperatively.
- **Structured to Exploratory**: Teachers move away from rigid activities geared toward classroom control to open-ended activities and projects.

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- **Competitive to Cooperative:** Teachers involve students in fewer isolating, competitive activities and more activities that involve collaboration and cooperation.
- **Classroom to Whole-World Interaction:** Teachers expand the context of learning from issues and resources available in specific content areas to "real-world" problems requiring interdisciplinary awareness and multiple resources.

These shifts may require many teachers to re-examine their professional beliefs and adjust their teaching styles accordingly.

What Expanded Roles Will Teachers Assume?

Teachers who use technology in their new roles do not have more work to do; on the contrary, these teachers are working smarter, not harder. Changing roles simply means doing things differently, in ways that can make teaching and learning more professionally fulfilling and instructionally effective. Using technology increases efficiency and productivity, freeing teachers to devote their time and energies to teaching.

The Christa McAuliffe Institute for Educational Pioneering has identified five key roles for technology-using teachers of the 1990s (Roberts, 1989):

- The **Collaborator** shares knowledge with colleagues and initiates and nurtures relationships that expand the boundaries of the classroom.

"Join me in welcoming our new staff members. Mr. Simpson, art. Ms. Dawes, science. Mr. Silbert, computer repairman."

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- The **Mentor/Mentee** teaches and learns from students, the community, and colleagues.
- The **Planner** creates a vision of the future, develops methods to achieve that vision, and structures the revised learning environment.
- The **Researcher** accesses, analyzes, and organizes information in order to guide students in understanding problem-solving strategies and developing discovery and learning skills.
- The **Seeker** ventures outside the classroom to gain new ideas and resources.

As teachers assume these new roles, the emphasis of their instructional practice shifts from product to process; however, the change process itself can be initially frustrating and elusive. Why? Because change takes time. One report suggests that "between three and five years are necessary to fully integrate an innovation such as educational computing into a school's curriculum" (*New Designs for Elementary School Science and Health*, 1989, p. 65-66).

What are the Stages of Instructional Evolution in Technology-Rich Classrooms?

Teachers pass through several stages as they use computers more often and more effectively. ACOT—the Apple Classroom Of Tomorrow—has documented five stages that teachers go through as they make greater use of computers in the classroom. As ACOT teachers explored uses of technology over several years in multimedia classroom environments, their patterns of instruction evolved through **Entry, Adoption, Adaptation, Appropriation,** and **Invention.** In this model, "text-based curriculum delivered in a lecture-recitation-seat work mode is first strengthened through the use of technology and then gradually replaced by far more dynamic learning experiences" (Dwyer et al., 1991, p. 46). These stages are described in Table 1 on p. 22.

DYNAMITE IDEAS:

MASTERY IN LEARNING

Winston-Salem, North Carolina, is one of five sites nationwide participating in the Mastery in Learning consortium, the second generation of the Mastery in Learning project launched by the National Education Association (NEA) in 1985. The project fosters school improvement by helping faculties apply up-to-date research and technology to teaching and learning.

To ensure that schools have adequate support, the NEA assigns each site a liaison from its headquarters and provides computer tie-ins to link the schools with other schools and universities across the country. The NEA also sponsors regular sessions at which school representatives meet to share ideas and update their progress.

As a result of their membership in the consortium, Konnack Elementary School, Philo Middle School, and Parkland High School have initiated inter-school collaborations to address issues such as curriculum integration, student transition from school to school, and budget issues. According to Superintendent Larry Coble, the project has also provided "the structure to really attack reinvention of the schools" (Diegmueller, 1991, p. 7).

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Table 1.
Five Stages of Classroom Computer Use and Integration

PHASE	TECHNOLOGY	PEDAGOGY	TEACHER OBSERVATIONS
Entry	Text	Lecture	Teachers become accustomed to a transformed physical environment that includes computers. Once instruction begins, first-year problems of discipline, resource management, and personal frustration must be solved.
Adoption	Text	Lecture Recitation Seatwork	Concerns shift from manually connecting computers to using them. Technology is used primarily to support traditional text-based drill and practice.
Adaptation	Text High Computer Access	Lecture Recitation Seatwork Play Experimentation	The new technology becomes thoroughly integrated into traditional classroom practice. Traditional pedagogy dominates student tasks, but is supplemented 30-40 percent of the time with the use of word processors, databases, graphics, and Computer Assisted Instruction.
Appropriation	Text	Lecture Recitation Seatwork Individualized instruction Cooperative learning Simulation Interdisciplinary approaches	Teachers achieve greater personal mastery of the technology. Simultaneously, teachers' roles begin to shift and new instructional patterns emerge. Team teaching, interdisciplinary project-based instruction, and individually-paced instruction become more and more common. Teachers even alter the foundation of the traditional school day: the master schedule. There is an increasing tendency of teachers to reflect on teaching, to question old patterns, and to speculate about the causes behind changes they are seeing in their students.
Intervention	Immediate Computer Access	Interaction Doing Creating	Teachers view learning as a more active, creative, and socially interactive process than when they entered the program. Knowledge is viewed more as something children must construct and less something that can be transferred intact. The nature of teachers' classrooms, the educational latitude they grant their students, and their own instructional behaviors demonstrate this shift in action.

ERIC Full Text Provided by ERIC

Teachers exposed to technology-rich classrooms in the ACOT project changed their instructional attitudes and methods significantly, but only after they confronted their own deeply ingrained beliefs about schooling:

> Most teachers entering the program never dreamed they would alter their instructional approach or broaden their perspectives about what children should and should not, or could and could not, accomplish in their classrooms. The direction of their change was toward child-centered rather than curriculum-centered instruction, toward collaborative tasks rather than individual tasks, and toward active rather than passive learning. Each of these dimensions brought deeply-held beliefs about real schools into conflict with emergent awareness about instruction and learning (Dwyer et al., 1991, p. 50).

Since change is often uncomfortable, a key element in the ACOT model is support for teachers as they re-examine long-standing and sometimes cherished beliefs about teaching. At the Entry stage, planning time was crucial. Hardware and software training were important in the Adoption stage. The Adaptation stage emphasized advanced training, consideration of alternative pedagogies, flexible scheduling for peer observations, and team teaching. By the Appropriation stage, teachers were routinely observing one another, examining the consequences of the changes they were experiencing, and investigating alternative assessment possibilities. Collaboration was the hallmark of the Invention stage, as teachers published their experiences, served as mentors, and used telecommunications to make contacts outside their district.

What are Some Characteristics of Accomplished Computer-Using Teachers?

Sheingold and Hadley (1990) conducted a nationwide survey of 608 teachers recognized for their experience and accomplishments in integrating computers into their teaching. The resulting profile offered some valuable insights. The majority had been teaching 13 or more years and were between 40 and 49 years old. Ninety percent indicated that they were largely self-taught and had often pursued opportunities to learn about technology at their own expense and on their own time. These teachers were slightly more likely to be from economically disadvantaged schools, yet their schools had more than twice as many computers as the national average. About 42 percent of their colleagues used

DYNAMITE IDEAS:

GEORGIA CLASSCONNECT

Four high schools and four colleges in Georgia are participating in a distance learning trial project entitled ClassConnect. Sponsored and supported by Southern Bell, NEC America, Vidicom, and KA Teletech, the trial enables a teacher at any one of the eight sites to teach a group of students at any or all of the other seven sites. Students and teachers at the different sites are able to interact fully and completely; cameras and microphones capture the images, data, and sounds that are transmitted in less than seven ten-thousandths of a second to video monitors and speakers at other sites.

The network utilizes a T1 cable, which is the equivalent of 24-voice telephone lines. Classrooms are equipped with monitors, cameras, instructor- and ceiling-suspended microphones, a facsimile machine, a document camera, and a personal computer which can control the equipment at each location.

Participating schools are the University of Georgia (Athens); Frederick Douglass and Grady High Schools, Morris Brown College, and the Georgia Institute of Technology (Atlanta); and Carver and Columbus High Schools and Columbus College (Columbus). The network is in place 24 hours a day and is used for seminars, special events, and by the community as well as for classes.

continued . . .

ERIC Full Text Provided by ERIC

GEORGIA CLASS CONNECTION continued...

In addition to offering courses in foreign language, history, writing, and communications (courses in adult literacy are also planned), ClassConnect provides high school teachers with training via link-ups with the colleges and universities. The network has had another, unexpected benefit: teachers watching their colleagues conduct classes have learned methods and strategies which they then incorporate into their own teaching.

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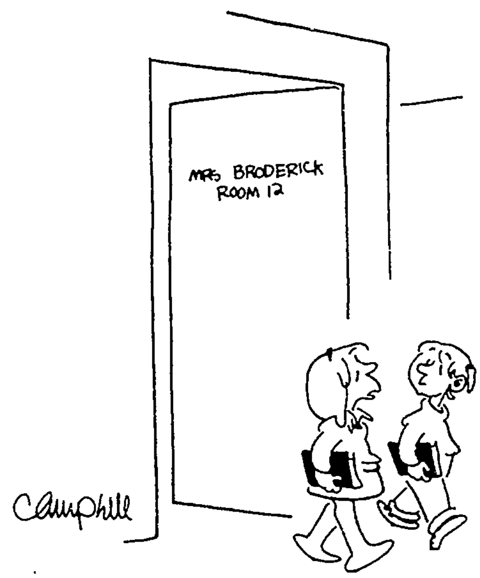
Common characteristics of accomplished computer-using teachers are a willingness to change, accept new roles, and grant students new responsibilities.

technology for instruction and 77 percent had regular on-site assistance available from a variety of sources (e.g., other teachers, site or district computer coordinators). In addition to these demographic characteristics, accomplished computer-using teachers said that they

- devoted considerable time and effort to using computers as multipurpose teaching tools;
- encouraged students to use these tools effectively for their own learning;
- changed their teaching with regard to higher expectations about student performance, individualization, and independence;
- changed their teaching roles; and
- spent up to six years mastering computer-based teaching practices and approaches.

Other common characteristics of accomplished computer-using teachers are a willingness to change, accept new roles, and grant students new responsibilities. Sheingold and Hadley (1990) conclude that three conditions are necessary to help teachers become more technologically literate:

1. Access to adequate technology resources,
2. Ample time to learn how to use technology and plan for its use, and
3. A school structure and culture which supports and encourages a professional and experimental approach to their work.



"Mrs. Broderick isn't as user-friendly as our teaching machines."

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TRAINING FOR THE FUTURE

To reduce computer anxiety and foster genuine technological change, staff development training should be matched to teachers' progressive needs, abilities, and comfort levels. Until recently, the lack of practical experience with educational computing made it difficult to define what teachers should be trained to do.

What Computer Competencies Do Teachers Need?

Most preservice and inservice computer training for teachers has emphasized skill building, the mechanical operation of hardware, and familiarity with specific software products. While skill building is necessary, mere computer literacy is no longer sufficient. Information-Age learning environments require teachers to apply their knowledge of teaching with computers in the classroom. Recognizing this shift in emphasis, Stakenas et al. (1990) suggest five areas of computer competence for K-12 classroom teachers:

1. **Basic knowledge about computer technology**—a general understanding of how computers work and the ability to use basic computer terminology and discuss the social, economic, and ethical impact of computers on society.

If computer technology is to have an impact on teaching and learning, teachers must be comfortable with computers, seeing them as tools that enhance rather than interfere with their daily teaching. For this to happen, teachers need special training.

Office of Technology and Assessment, 1988

2. **Equipment operation skills**—the ability to perform standard computer operating procedures (e.g., formatting disks, loading and running programs, saving files, printing documents) as well as troubleshooting for minor problems. Teachers should use a variety of input and output devices and use projection devices (LCD panel), interactive videodiscs, and modems as part of their instruction.

3. **Productivity tools skills**—the ability to use and teach word processing, database, spreadsheet, graphics, and desktop publishing software.

4. **Instructional application skills**—the ability to evaluate and utilize different types of more specialized computer software (e.g., drill and practice, tutorials, simulations, problem-solving) to accomplish specific educational objectives. The ability to integrate appropriate applications of the computer in a variety of content areas, using a variety of teaching/learning strategies, and design customized multimedia learning activities.

5. **Management application skills**—the ability to use computers to manage and complete tasks such as record keeping, progress reports, report cards, attendance, worksheets, tests, letters to parents, and grade books. The ability to use electronic mail and Local Area Networks (LANs).

Rapid changes in computing technology and its growing impact on education require teachers to have a solid preservice education upon which inservice training can build.

M.L. Neiss
Preparing Computer-Using Educators in a New Decade, 1990

The implications of these enhanced computer competencies are twofold: computer knowledge and experience must be upgraded regularly and teachers must use technology to teach. Therefore, teachers need technology training, but they also need technology education. That is, they need to know not only how to operate the technology to meet their goals, but also how to work with it in changing their goals in response to the new possibilities opened by technology (Office of Technology Assessment, 1988).

The distinction between technology training and technology education is crucial because of its bearing on the preservice and inservice computer education teachers receive. Rapid changes in computing technology and its growing impact on education require teachers to have a solid preservice education upon which inservice training can build (Neiss, 1990a; Neiss, 1990b).

How Should Preservice Computer Education for Teachers be Structured?

Because nearly all teachers will face the prospect of using computers in their instruction in one way or another, preservice educators must have the knowledge to provide relevant technical training and specific education on the classroom uses of computers. At present, only half the states "require or recommend preparation in technology for their new teacher education graduates" (Olson, 1992, p. 18), which means too many teachers have to play catch-up and learn on the job.

Many professional organizations, some state departments of education, and the National Council for Accreditation of Teacher Education have begun to exert their influence on colleges of education to better prepare prospective teachers in the use technology.

Neiss (1990a, 1990b) recommends that preservice teachers use computers throughout their entire program of study, both as a means to learn their subject matter and to prepare for their vocation. A single course on computers in education taught during the junior or senior year will not meet this recommendation. Stakenas et al. (1992) propose that the foundation in basic instructional technology for all undergraduate preservice teachers include the following:

1. **A comprehensive course in computer applications**—to provide students with a moderate degree of mastery with word processing, database management, spreadsheets, and perhaps graphics software—ideally with a variety of hardware platforms.

2. **A comprehensive course in instructional technology**—to acquaint students with the basic capabilities of various technologies available for use in education and the skills to operate this equipment.

3. **Inclusion of instructional applications using a wide range of technologies in the methods courses for specific subjects**—foundation and methods courses, seminars, and practice teaching situations which include discussions and demonstrations of appropriate ways to integrate technology and teaching.

All of these courses would emphasize that the curriculum, not technology, is to be the driving force in today's restructured learning environments. Furthermore, professors would model the use of technology in their own instruction.

DYNAMITE IDEAS

MISSISSIPPI FIBERNET 2000 DISTANCE LEARNING PROJECT

Mississippi FiberNet 2000 is a public/private partnership providing fiber optic-based distance learning for students, enrichment and inservice programs for teachers, and data networking. The program is sponsored by the State of Mississippi in cooperation with South Central Bell, Northern Telecom, IBM, ADC Telecommunications, and Apple Computer. Teachers and students at different locations can see, hear, and interact with each other at all times.

Designed to expand learning opportunities in small, isolated, and rural school districts, Mississippi FiberNet 2000 offers courses such as foreign languages, mathematics, creative writing, communications, and computer applications. Without leaving their schools, students "attend" classes at the Mississippi University for Women, Mississippi State University, the Mississippi School for Math and Science, and at the studios of the Mississippi Educational Television Network.

Teachers can also take classes and inservice through the program. Mississippi FiberNet 2000 fosters collaboration among teaching colleagues: teachers at remote sites on the network form collaborative teams, work together to develop curricula, and share teaching responsibilities (*Mississippi 2000*, 1991).

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Some colleges of education have begun to implement these changes. Career teachers typically spend four years in an undergraduate program preparing to teach and as many as 20-30 years in the classroom. The rapid evolution of hardware and software means that they will experience many completely new generations of computer technology during this time. Because of these regular technological advancements and because changing the structure of preservice education will take a great deal of time, inservice training will remain the most important way for teachers to become technologically literate and stay current.

The rapid evolution of hardware and software means that teachers will experience many completely new generations of computer technology during their careers.

How Should Technology Inservice Education be Structured?

Teachers spend many hours attending inservice sessions designed to effect changes in their instructional practices. These changes are often multi-dimensional, requiring re-examination of the philosophies underlying instructional or managerial beliefs and methods. Such changes, especially when computers are involved, are neither easy nor simple. Unfortunately, the desire to train many teachers to integrate computers into their instruction as quickly as possible can conflict with teachers' needs to move slowly, overcome fears, and develop ownership of the new technology through guided, hands-on training. The single, "intensive" technology inservice, with its smorgasbord of activities, will often fail to meet the various and complex training needs of teachers.

As described earlier, the Apple Classroom Of Tomorrow experience indicates that teachers evolve though several stages as they integrate computers into their instruction. Consequently, technology inservice training should be designed to complement the changes which occur in teacher practice and should be responsive to a teacher population consisting of members at varying stages. A model framework for this type of training has been developed by the Minnesota Technology Demonstration Site Program (Office of Technology Assessment, 1988). It organizes the progression of inservice technology training topics into five stages:

1. **Awareness:** large group workshops that give teachers a general overview of how technologies work and also help alleviate anxiety;
2. **Overview:** workshops that deliver additional detail on how particular technologies work and usually provide examples of the application of technology to particular subject areas;
3. **Topical:** small groups that focus on a specific area (e.g., math or science);

4. **Adoption/Implementation:** intensive work by each participant, focused on an area of specialization; and
5. **Integration:** fine-tuning curriculum materials that use technology or guided assistance to integrate technology into lessons.

This natural progression accommodates changing needs, abilities, and comfort levels as teachers' technical skills and pedagogical practices evolve. Using this framework, it is possible to design an effective and efficient staff-development program that provides both enjoyable and useful learning.

Utility and practicality are important considerations. Teachers are wary of intrusions on their limited time; they weigh the value of training against the professional obligations that could have been met during the training time: planning lessons, grading papers, helping students, meeting with parents, etc. Consequently, inservice computer training must emphasize practical classroom use above all. Cuban (1986) found that

> teachers will alter classroom behavior selectively to the degree that certain technologies help them solve problems they define as important and avoid eroding their classroom authority. They will either resist or be indifferent to changes they see as irrelevant to their practice, that increase their burdens without adding benefits to their students' learning, or that weaken their control of the classroom. The implicit password that opens the classroom teacher's door to innovations of any type, including computers, is PRACTICALITY (p. 71).

Clemente (1991) offers the following guidelines for designing technology inservice training that is both practical and useful:

1. Complete a needs assessment in which teachers participate in identifying topics of interest. This permits detailed and organized scrutiny of actual training requirements.
2. Allow teachers to collaborate with the principal in setting goals and planning the inservice program. Individuals are more likely to support consensus-based goals.
3. Conduct inservice at the school. School-based programs are more convenient and applicable than off-site programs.
4. Have teachers taught by experienced peers. Knowledgeable teachers using relevant and successful classroom-

DYNAMITE IDEAS:

RESTRUCTURING THROUGH TECHNOLOGY

In 1990, Shelby School District in North Carolina adopted a classroom organizational model developed by IBM called Teaching and Learning with Computers. The program, which is child-focused and guides students through various learning centers, is the centerpiece of the district's restructuring efforts. Graham Elementary School served as a pilot site for the program; each of the school's 12 classrooms is equipped with five personal computers networked to two file servers.

The approach at Graham Elementary is interdisciplinary and designed to change the teacher's role from lecturer to facilitator of learning. Classrooms are divided into listening, writing, computer, math, and research centers, and students move from one center to another to work cooperatively on their lessons. A voice synthesizer on the computers appeals to auditory learners.

The success of the program at Graham Elementary prompted teachers at Shelby High School to ask to join in the program. Teachers at the high school developed their own models for teaching with the learning center approach and use technology to allow students to learn at their own pace. Shelby schools have shown improvements in test scores, fewer discipline problems, and higher attendance rates (Bryson, 1992, pp. 11-14).

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DYNAMITE IDEAS:

Teacher Technology Training

Webster Elementary School in St. Augustine, one of Florida's five Model Technology Schools (see *Dynamite Idea* page 15 and Appendix B, p.69), placed a special focus on staff development in order to make all school personnel comfortable using technology on the job. Training began even before new software and hardware arrived, and applied several logical (but too often overlooked) principles:

- All school staff (e.g., teachers, administrators, and clerical support) were given training,
- Training was given only on hardware and software systems that the staff would use regularly,
- Staff were allowed to take software and hardware home to practice overnight, on weekends, on vacations, and during the summer,
- Regular time was designated for on-site training (e.g., two days per week after school),
- Training was initially given in large groups, but evolved into smaller groups in response to changing needs, and
- Teachers were allowed to decide how to spend technology funding incentives (e.g., they chose to purchase additional hardware and software).

continued . . .

tested ideas are more credible with fellow teachers than outside experts.

5. Have teachers participate actively during the inservice. Include hands-on activities so teachers can determine whether new ideas or materials will work with their students.
6. Offer follow-up support. This may be the single most important factor contributing to the successful implementation of computer-based learning, because new issues and applications will occur to teachers over time.

In keeping with the new roles for teachers and the growing importance of inservice training, a new approach to technology staff development is also needed. The International Society for Technology in Education has developed a model for effective technology staff development known as the Computer Integrated Instruction Inservice, or CI^3 (Moursund, 1990). This model does not focus solely on a specific instructional technique, computer skill, or individual software competency. Instead, CI^3 strives to expand teacher knowledge and capabilities in the classroom while simultaneously providing an environment for exploring ways to integrate computers into the curriculum. Computer staff development of this type differs from typical inservice training in several ways:

- Each session offers participants at least one idea that can be used in their classrooms immediately or in the near future.
- Software is always introduced in an instructional context, using classroom examples, rather than simply as a program to be mastered.
- Participants experience activities from two perspectives: as "students" learning the inservice content and as "teachers" evaluating how activities can be used in the classroom.
- Participants work in groups to discuss computer-related curriculum matters and build a school-level or district-wide resource base.
- Sessions are structured to allow participants to discover their own methods and models of instruction rather than being limited to achieving a single objective.

In addition, Stakenas et al. (1992) recommend that technology inservice should use the kinds of hardware and software that teachers have in their own classroom or school and that teachers be grouped homogeneously (based on expertise) to avoid frustration for novices and boredom for more advanced users. Different training sessions should be offered to participants according to subject area or instructional responsibility.

What Role Do Administrators Have in Technology Education?

Administrative support from the principal, school board, and superintendent are crucial to the successful implementation and use of technology from the classroom to the district level. Administrators and teachers often develop different perspectives on the benefits and uses of technology; this can result in conflicting needs and expectations regarding the instructional applications of computers. Fostering and maintaining administrative support can be as simple as inviting the principal to observe—or better yet—participate in computer training for teachers.

Administrators can also play a strong collaborative role. The process of technology inservice education requires an ongoing commitment from both teachers and administrators. Teachers must commit to upgrading their technology education regularly and administrators must agree to make such opportunities available. Clemente (1991) recommends that administrators can best support technology staff development by

- seeking teachers' advice when planning for long-range staff needs;
- finding creative ways to provide release time for teachers to participate in staff development;
- supporting new ideas and providing the necessary time for planning, learning, practicing, and seeking advice;
- budgeting the money necessary to assure long-term learning opportunities; and
- committing to provide follow-up until the new ideas are implemented.

Leadership in implementation may arise at any level. In the past, responsibility for implementing educational changes was delegated to district-level personnel, but the spirit and intent of restructuring imply teacher empowerment through shared decision making. Consequently, leadership is no longer necessarily a function of position. With regard to increased use of educational technology, the original grassroots movement has spawned a growing cadre of accomplished computer-using educators who understand the correlations among using technology, restructuring learning environments, and expanding roles for Information Age teachers.

These expanded and multiple roles—collaborator, mentor/mentee, planner, researcher, and seeker—herald a new era for the teaching profession, one that commands educators to exert their individual and collective leadership. D'Ignazio (1990) urges all teachers to become leaders and visionaries for change because it accomplishes the following:

TEACHER TECHNOLOGY TRAINING continued ...

As staff members began to feel comfortable with the technology, they were asked to identify specific hardware or software systems in which they had special interests or skills. Those who responded were given additional time and training to develop expertise in their respective interests. The new experts' names and areas of expertise were compiled onto "Hardware Expert" and "Software Expert" resource lists, and other staff now consult their "expert" colleagues for help and guidance with specific systems.

Webster Elementary's home-grown technology experts have become a valuable commodity not only at the school but also for the Florida Department of Education, which for the past two years has invited Webster teachers to conduct technology training for teachers and administrators around the state.

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improves the quality of their working environment, makes them more successful in teaching their students, and elevates their status in the eyes of their community and the educational establishment (p. 95).

These roles may be unaccustomed ones for many: the teacher as change agent has not been emphasized in the traditional educational hierarchy. Yet, the compounded effect of the expanded roles for teachers is nothing less than that of change agent. This may well be the most important new role for teachers of the 1990s and beyond.

Section 3

Instructional Practices that Promote Authentic Achievement

Using Technology to its Full Potential

- How *can* computers be used in the classroom?
- Are Integrated Learning Systems the answer?
- Are computers just tools?

Doing New Things in New Ways

- What shifts in practice can lead to creation of new learning environments?
- Which instructional practices facilitate authentic achievement?
- How can interdisciplinary projects and cooperative and problem-centered learning strategies be used in the classroom?

INSTRUCTIONAL PRACTICES THAT PROMOTE AUTHENTIC ACHIEVEMENT

Today we are asking teachers to stop teaching students isolated facts, to stop emphasizing rote learning, and to stop just covering material and preparing for multiple-choice tests. Instead we are asking them to start teaching students how to apply skills, how to understand concepts and solve problems, how to work collaboratively, and how to take responsibility for learning. In other words, we want teachers to give students the skills they will need to function in the work force and in society.

J. L. David
Restructuring and Technology: Partners in Change, 1991.

USING TECHNOLOGY TO ITS FULL POTENTIAL

How *Can* Computers be Used in the Classroom?

The lack of consensus about how to use computers is not too surprising given their relatively short history in schools, the diversity of grade levels and disciplines involved, and the dizzying evolution of hardware and software. Classroom computer use spans a continuum from maintaining the status quo to fostering new organizational patterns, curricular goals, and instructional practices. Lowd (1986) summarizes this diversity of uses: computers can

- create interactive learning environments where teachers facilitate students' tackling of real problems,
- encourage active learning and higher-order thinking skills, teach logic, critical thinking skills, and problem solving,
- individualize learning, and
- mechanize teaching and learning (p. 4).

These goals are unequal but not mutually exclusive. At one extreme the computer functions as a subject-driven tutor, while at the other it creates a unique, student-centered, and process-oriented learning experience—the essence of a restructured curriculum.

The flood of drill-and-practice and tutorial products on the market indicates that publishers believe the last two or three uses of computers in the above list have enough profit potential to warrant continued investment (Lowd, 1986). It is the first two applications, however, that most educators would like to see implemented; they complement the goals of school restructuring and encourage learning experiences that

- accommodate different rates, modes, styles, and strategies of learning,
- include access to information, expertise, and settings beyond the traditional school site,
- place increased attention and responsibility on the students, and
- address educational needs throughout the learner's lifetime.

(Thomas and Knezek, 1991)

Such learning experiences have always been the goal of Computer-Assisted Instruction (CAI), but until recently, managing the complexities of computer-based learning has been beyond both the computational power of hardware and the pedagogical capabilities of software. Using today's more powerful technology, however, the next generation of CAI—the Integrated Learning System (ILS)—is already being marketed to schools.

Are Integrated Learning Systems (ILS) the Answer?

These systems are a configuration of networked computers connected to a file server containing a variety of multi-level, multi-subject programs for instruction and practice. Students progress through a series of lessons based on continuous assessment of their achievement.

Many major ILS vendors have undertaken comprehensive curriculum-development projects. Costing between $60,000 and $120,000 for a lab of 20-30 stations, the systems are marketed to school districts on the basis of their potential to improve achievement gains, especially on standardized tests of basic skills (Newman, 1990).

Becker (1990a) lists six reasons why the ILS should help improve student academic achievement:

1. Computer-based activities are motivational.
2. Networked computer activities eliminate some of the logistical problems associated with stand-alone computers.
3. Centralized management functions enable teachers to design individualized skill practice for students with specific needs.
4. Diagnostic-prescriptive analysis systems can assess each student's specific skill deficiencies.
5. Tutorial capabilities can provide instruction for students with specific concept deficiencies.
6. A consistent user-interface available from a single ven-

dor can provide a complete multi-level, multi-subject curriculum that enables students to concentrate on learning tasks rather than on figuring out how each specific program works.

While these may seem to be compelling reasons to use Integrated Learning Systems, questions have been raised as to whether the ILS is the best approach. For example, an ILS product survey by the Educational Products Information Exchange Institute (EPIE) reported that

- Student satisfaction with an ILS was probably due to increased interactivity over paper and pencil drills and workbook exercises.
- Teacher satisfaction with an ILS was likely due to automatic individualization and record-keeping features.
- Teachers expressed some dissatisfaction with the ILS' repetitive instructional style, its placement of stations in labs rather than in classrooms, and the incompatibility of ILS software with other, more generally used software (Resta, 1990).

Do these systems work? Because statistically significant research is scant, the debate continues. Van Horn (1991) believes the ILS is capable of increasing the useful work output of schools exponentially, while Hopkins (1991) suggests that some schools may simply use the ILS as an insurance policy to guarantee that students get daily exercises to develop foundation skills. Furthermore, Newman (1990) warns that an ILS may provide strong support for a compartmentalized curriculum and inhibit teachers who want to change their instructional mode. After evaluating the results of 32 ILS research reports, Becker (1990a) concluded that research results were "too weak a reed on which school districts should base their acquisition and investment decisions" (p. 19).

Finally, the introduction of ILS again raises the specter of technology replacing teachers. True, an ILS *can* relieve teachers of many repetitive administrative chores and manage instructional skill remediation efficiently. But as a result, the student-teacher ratio is reduced and the teacher is freed to work with individuals or small groups needing personal attention while other students are engaged in computer activities. These systems are meant to *supplement* regular instruction (Van Horn, 1991) and allow teachers to assume new roles (Hopkins, 1991), not replace teachers. For example, experience with the Saturn Schools in Minnesota has shown that the ILS and other new technologies "are a powerful and necessary *adjunct* [italics added] to any transformed school effort" (King, 1992, p. 67) which support, not supplant, the teacher.

DYNAMITE IDEAS:

INTEGRATED LANGUAGE ARTS INSTRUCTION

Developed by teachers in Coffee County, Georgia, the Integrated Language Arts Instruction program is used by teachers as an extension of the language arts curriculum. The program is designed to both motivate reluctant writers and improve the fluency and effectiveness of all student writing. Following a plan developed by the language arts department, teachers develop units of instruction that integrate several software packages and encompass a variety of curriculum objectives. The curriculum is based on the whole-language approach, and activities are structured to foster process writing skills.

Scheduling of students into the school's computer laboratory is arranged several weeks in advance, with language arts teachers working as a team to ensure that lab activities are effectively integrated with classroom instruction. Four language arts classes are designated as lab classes each period, and students are scheduled into the lab a minimum of 22 days per semester to complete process writing and whole-language classes. The program ensures that all students receive at least one semester of computer instruction prior to graduation.

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DYNAMIC IDEAS:

MICROCOMPUTER-BASED LABORATORY FOR PHYSICS STUDENTS

In the Microcomputer-Based Laboratory for Physics Students at Winter Park High School, eleventh- and twelfth-grade students of all ability levels perform experiments with state-of-the-art laboratory equipment. The physics laboratory is outfitted with ten computer stations, each of which is equipped with probes to measure distance, force, temperature, heat, sound, magnetism, light, and electricity. The computers even have Geiger counters, and are networked to two printers so students can print and analyze results.

In the lab, students perform guided, but relatively unstructured experiments in introductory physics. Since a computer can collect and process more data in minutes than a person can gather in hours or days, data is generated and analyzed very quickly, and students can conduct several runs using a variety of approaches within a single lab period. As a result, students gain a deeper understanding of physics concepts.

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"It's a note on a floppy disk from my teacher -- too bad we don't have a computer."

Reprinted with permission of the artist.

Are Computers Just Tools?

The pervasive image of the computer as a tool carries many latent Industrial-Age connotations. Tools are used to repair or fix things, to do labor-intensive, manual work. But tools are also used to create things: furniture, sculpture, and automobiles. An innovation that allows artists to mix pixels with a mouse rather than paints with a brush, allows students to produce rather than reproduce knowledge, or allows an architect to "walk through" a building not yet constructed is clearly a different kind of tool.

Computers are multi-dimensional. They *are* tools, but they are also much more; computers are an entirely new medium. Computers are not inherently better than any other instructional medium, just more versatile. The cognitive and affective skills involved are often quite different from those used with traditional media. Writing a report using a word processor is different than using pencil and paper or even a typewriter. Conducting a lab experiment simulation on a touch-sensitive screen is different from using real chemicals and beakers. The versatility of the electronic medium must be emphasized and exploited so that teaching and learning can be accomplished in the new, imaginative ways that a computer makes possible.

A third dimension, the computer as a context, is gaining widespread attention. This application grew out of early on-screen simulations of various phenomena. Papert (1980) used the term *microworld* to describe a computer-based simulated learning environment that could be controlled to explore relationships among objects and events. In such a microworld, students might explore the physical principles of launching a satellite from planets with different gravities. The latest incarnation of this concept, virtual reality, "places" the user inside an artificial environment. Using a three-dimensional, head-mounted display and a data glove, a user can "enter" the computational space, look at its features, walk through it, even change it. The environment exists only within the context of the computer-created simulation. In a practical application of this technology, a medical student could use a "virtual scalpel" to operate on a "virtual cadaver" to practice surgical skills (McLellan, 1992).

This hierarchy of metaphors—computer as tool, as medium, and as context (Gittinger, 1989)—currently defines the existing and emerging uses of Information-Age technology. To prepare students to use technology in these ways, teachers must translate these multidimensional capabilities into appropriate classroom activities:

> A 'restructured' vision of the goals of education seeks to evaluate performance activities that are worthwhile, significant, and meaningful: in short, activities that are authentic (Newman, 1991, p. 459).

The current challenge for computer-using teachers is to develop practices and devise activities that foster authentic achievement.

DOING NEW THINGS IN NEW WAYS

What Shifts in Practice Can Lead to Creation of New Learning Environments?

While changes in the master schedule, curriculum, classroom seating arrangements, and access to technology are integral components of new learning environments, the teacher remains the critical element. Teachers must use innovative methods that model new goals and approaches. What does this mean in practice? Restructured learning environments will be characterized by shifts from

- passive ingestion of information to active construction of knowledge,
- end-of-chapter textbook questions to "real-world" issues,
- tabulating and graphing data to use of data-gathering tools,
- plotting data to testing hypotheses,
- predetermined to preferred learning styles,
- assessment based on recall of isolated facts to measurement of complex, higher-order thinking skills,
- single to multimedia, and
- literal to critical evaluation.

(Dede, 1991; Thomas and Knezek et al., 1991)

DYNAMITE IDEAS:

COMPUTER CONNECTIONS

Fifth and sixth-graders from all ability levels at Marion Elementary School participate in the Computer Connections program. Sixty-three percent of the students are minorities, 51 percent come from single-parent families, and 61 percent receive free or reduced-price meals at school. The school is located in a rural county with the lowest taxable income in South Carolina.

Computer Connections was developed to help students achieve proficiency in writing and enhance their ability to interact with technology; it is a complete writing program beginning with paper and pen and ending with a professionally bound book complete with student graphics and a laminated cover. This process also provides students with experience in layout, graphics, and editing.

Projects include *Big Books* (student autobiographies), cross-cultural publications featuring holiday customs, therapeutic compositions dealing with individual problems, and learning books produced to be used by primary students. The program also allows students to use database files to conduct research for various types of publications such as travel brochures, class papers, and special-interest books.

As a result of the project, reading, writing, and language scores have increased and so have parent and community involvement with the school.

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SOURCES OF TECHNOLOGY FOR COOPERATIVE AND PROBLEM-CENTERED LEARNING

Several companies offer computer software or other technology-based programs which promote cooperative learning and problem-centered instruction. Two such companies are described below. Note: descriptions of these catalogs, which offer items for sale, does not represent an endorsement of their products by SERVE.

Sunburst Communications
1101 Castleton Street
Pleasantville, NY 10570-3498
(800) 628-8897

This free catalog advertises computer software for teaching all subject areas at any grade level. Computer programs for teaching problem-solving strategies through such activities as logic puzzles, simulated manufacturing, or building a gear factory are available. Simulated science experiments include keeping outer space creatures alive in the classroom, creating planets, or growing plants under various conditions. The software may be used for problem-centered activities or can provide teachers with ideas for lessons.

Tom Snyder Productions
90 Sherman Street
Cambridge, MA 02140
(800) 342-0236

This free catalog describes activity books, laser disc and computer programs, and other tools for teaching at any grade level. Problem-solving activities can be found in such activities as mathematics mystery games, cooperative-learning videotapes and a simulated geological expedition. These activities may be used to create problem-centered lessons or to help students search for solutions.

Which Instructional Practices Facilitate Authentic Achievement?

> Because computers and other technologies are used more effectively with group learning and participation, they require a different set of teaching strategies from the individualization and competition we are used to in our classrooms.
>
> S.J. Corda
> *Implementing Technology in Schools,* 1991

There are many practices, strategies, and techniques teachers can utilize to facilitate authentic achievement. Three strategies which can be enhanced by the infusion of technology include **interdisciplinary projects, cooperative learning, and problem-centered learning.**

In the content-centered curriculum, subjects are often taught in isolation. The need to cover a prescribed set of objectives in a limited amount of time often prevents drawing parallels or connections with other subjects. As a result, students may have difficulty integrating knowledge and extrapolating to new areas. Thomas and Knezek (1991) argue that artificial subject-area and classroom boundaries must be dissolved to create a "seamless" curriculum. **Interdisciplinary projects** foster the drawing of connections among subject areas and promote active involvement. Students can work individually or cooperatively, and teachers can teach the content separately or as a team.

A second instructional practice well-suited to a restructured learning environment and the use of technology is **cooperative learning.** Unlike competitive or individualized approaches, cooperative learning encourages students to work in groups and collaborate to accomplish goals. As noted by Hilke (1990), the "goals of cooperative learning are to foster academic cooperation among students, to encourage positive group relationships, to develop students' self-esteem, and to enhance academic achievement" (p. 8).

As noted earlier, placing computers in a classroom does not ensure their effective use, and putting students into groups does not guarantee that cooperative learning will occur. The social skills necessary for successful cooperative learning (effective communication, conflict resolution, team building) must be taught and modeled. Students also need well-defined roles and responsibilities when cooperative learning is used. Because computer resources are often limited, and since students generally enjoy working with one another on the computer, cooperative learning is an ideal strategy to use in restructured learning environments.

Problem-centered learning is a third strategy for encouraging authentic achievement. A spin-off of cooperative learning, it relies on small-group interaction followed by whole-class negotiation to explore and develop solutions to problems. A problem-centered learning approach teaches students three important learning skills; they learn to

- discover concepts and solve problems—instead of simply reading facts and then answering textbook questions or completing workbook exercises,
- think—not just memorize, and
- cooperate in small groups—not compete against each other (Kadel, 1992).

Problem-centered learning is especially relevant to mathematics and science teaching because it promotes the development of problem-solving skills through exploration and discovery. In many situations, individuals approach a new task with prior knowledge; as they assimilate new information with what they already know, they actively make sense of experiences in a personally relevant way. Problem-centered learning encourages students to use this process when starting to learn new material or when looking for answers to their own questions about how the world works (Kadel, 1992).

How Can Interdisciplinary Projects and Cooperative and Problem-Centered Learning Strategies be Used in the Classroom?

This is best demonstrated by example. Teachers at all grade levels, regardless of subject area, often assign reports as they go through their sequence of objectives. Typically, the teacher assigns the topic and students conduct library research, then write a report. The teacher seldom has the time or proper training to guide students through the painstaking procedure of report writing; instead, it is frequently assumed that the English teacher has patiently guided students through the paper-production procedure. While this is often the case, students do not necessarily see the connection between the research/writing skills they develop in English and the need to synthesize information and communicate intelligently in other subject areas. There may be little skill or knowledge transfer when students are asked to do something out of the normal "context" (i.e., writing a report in science class or calculating grades in an English class.).

On the following pages, three hypothetical scenarios are presented. The first two show how "writing a report" might take place in interdisciplinary and cooperative settings. A third scenario illustrates a problem-centered approach to a middle-school science lesson. These examples are not meant to define a strategy or fully describe a lesson plan, but to show the potential of new, technology-using approaches to learning and teaching.

ERIC Full Text Provided by ERIC

SCENARIO ONE (Interdisciplinary Approach)

Teachers: Mrs. Wright, 14 years experience; recently completed technology inservice
Mr. Ellis, 12 years experience; intermediate computer experience
Setting: Second-period World History
Class: 32 juniors seated in clusters
Scene: Just finishing the history textbook chapter on World War II
Resources: One classroom computer, library books and encyclopedias, and assorted software; a second computer with a modem is available

Discussion

Mrs. Wright: To wrap up our study of World War II, we're going to do a project with Mr. Ellis, your English teacher.
Elizabeth: What kind of project?
Mr. Ellis: We'll combine your study of World War II in social studies with the writing skills we've worked on in English.
Roland: Do we have to write a report?
Mrs. Wright: No—at least not the kind you're used to.
Mr. Ellis: The next issue of the school newspaper is devoted to the conflict in the Middle East. We'd like you to compare what happened in World War II to what is happening over there today.
Martha: How can we do that? We're not newspaper reporters.
Mrs. Wright: True, but you have access to much of the same information as reporters.
Kareem: My grandfather was in World War II. I could interview him about his experiences.
Mr. Ellis: Sure, and we just found out we can send and receive E-mail to the soldiers in the Middle East using the modem on the journalism computer.
Cindy: You mean I could contact my cousin? She got sent over there a month ago.
Mrs. Wright: Of course. She could give us an account from a woman's perspective.
Scott: We could also use the newspaper.
Mr. Ellis: How would you use the newspaper, Scott?
Scott: Well, the paper's full of stuff about the Middle East. We could read newspapers on microfiche from World War II at the downtown library. There should be some interesting differences in the way the press has covered each war. TV coverage would be different also.
Mrs. Wright: *Very* different—no one *had* TVs back then. They were able to see the news, however; why don't you find out how? We'll spend the next three weeks on this. It's worth fifteen percent of your grade in each class. I'll be interested in your historical comparisons.
Mr. Ellis: And I'll help you polish your writing skills. When you finish, we'll publish your reports with our new desktop publishing software.
Shawn: When do we start?
Mrs. Wright: Get going!

SCENARIO TWO (Cooperative Approach)

Teacher:	Mrs. Panza, 8 years experience; intermediate computer experience
Setting:	Sixth-period World History
Class:	28 sophomores, juniors, and seniors seated in clusters of four
Scene:	Just finishing the history textbook chapter on World War II
Resources:	One classroom computer, library books, and encyclopedias

Discussion

Mrs. Panza:	To wrap up our study of World War II, we're going to do a group project.
Tony:	On what?
Mrs. Panza:	I'd like you to compare World War II to the conflict in the Middle East.
Michelle:	Can we compare anything we want?
Mrs. Panza:	Yes, but it must be a group decision and related to the themes we've been studying. You'll have to use of the cooperative skills we have developed on other projects to design a multimedia presentation.
Arnold:	What are the roles this time?
Mrs. Panza:	Each group will have a project manager, a text editor, an image librarian, and a graphics designer. Also, in this project you will create a GUI [pronounced gooey].
Shana:	A GUI?
David:	GUI stands for Graphical User Interface. Instead of screens with text menus, you use picture icons to make choices. We did that in our whale project for marine biology.
Mrs. Panza:	Right! That was a good example.

After being assigned to groups and receiving their role assignments, the students gather to brainstorm and reach a consensus about their project. Mrs. Panza moves among the groups, observing and facilitating.

Mrs. Panza:	All right, let's have each group briefly share its plan with the class.
Peggy:	We're going to compare the weapons used in World War II with the ones used in the Persian Gulf War. As project manager, I'll help keep everyone on task.
David:	Hey, that's what our group wanted to do!
Mrs. Panza:	OK, but let's hear what they have to say first. You may be able to work something out.
Ken:	I'll type and edit the text on each screen.
Mrs. Panza:	Will you also write the text?
Peggy:	We'll all help with the research. We can design a form and fill it in with specific information about each weapon.
Alberto:	There are lots of books on World War II in the media center.
Shana:	And there are some videodiscs in the media center.
Ken:	We'll have to decide what to include, and then I'll type the information on each screen.
Mrs. Panza:	Good plan so far. Alberto, what's your job?
Alberto:	I'm the image librarian. I've got to find pictures that we can scan or capture from the videodiscs on each weapon.
Mrs. Panza:	What kind of images?
Alberto:	You know, pictures of missiles, bombs, planes, tanks. Things like that.
Mrs. Panza:	What else can you show about these weapons?
Peggy:	We could show the destruction they caused.
Shana:	We could compare how powerful they are.
Mrs. Panza:	Sounds interesting. Shana, what is your role?

Shana: I'm doing the graphic design for each screen, the GUI. I can use the clip art collection or draw my own icons.

Mrs. Panza: Any ideas yet?

Shana: Sure, we could use planes, ships, tanks, soldiers, and rockets.

Mrs. Panza: Seems like a big project!

Peggy: How much time do we have?

Mrs. Panza: We'll spend the next three weeks on this. You haven't asked yet, but it will be twenty percent of your grade. As usual, you'll get a group and an individual grade.

Alberto: I don't know if we can do what we want to do in just three weeks. It will take a lot of time just to do the research and then to decide what to put on each screen before we even get to the computer.

Mrs. Panza: Time is important. Can you think of any alternatives?

David: Mrs. Panza, our group wanted to do weapons too. Could we work together? Maybe their group could do one war and we could do the other.

Peggy: That's a good idea. We could get a lot more done that way. We'll probably have to use the computers in the media center as well.

Mrs. Panza: It's fine with me. You'll have to work out the details among yourselves. Let's hear what the other groups want to do.

SCENARIO THREE (Problem-Centered Learning Approach)

Teacher: Ms. Hughes, 23 years experience; advanced computer user

Setting: Third-period general science

Class: 36 sixth-, seventh-, and eighth-graders seated at six student learning centers

Scene: Just beginning a unit on sound

Resources: Three computer lab stations equipped with printers and assorted probes, reference books, and magazines

Discussion

Ms. Hughes: This week we've been studying sound. Who can recall what you observed in yesterday's experiment? Russell?

Russell: We put different amounts of water in glasses and when we hit them with a pencil, they made different sounds. We used the sound probe attached to the computer to show the differences on a graph.

Ms. Hughes: Did the amount of water affect the sound that was made?

Russell: Yeah. The more water in the glass the lower the sound.

Cynthia: And the higher sounds gave higher peaks on the graph.

Ms. Hughes: Good observations. Now notice what I have here. You can't see it yet, but behind this screen I have three glasses. Listen as I tap each one.

Amelia: They're different. There must be different amounts of water in each.

Ms. Hughes: Can someone state a hypothesis?

Matthew: The sound depends on the amount of water in a glass.

Shannon: The more water you have in a glass, the lower the sound will be when you tap it with something.

Ms. Hughes: "Sounds" to me like you understand this pretty well. I'm going to lower the screen, and let's confirm your hypothesis.

Andrew: Hey, you tricked us! Each glass has the same amount in it!

na: But they're different colors.

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Mark: Are they different liquids?
Ms. Hughes: Let's discover some answers.

Each group decides on one hypothesis to test. Ms. Hughes moves among the groups, facilitating their investigations.

Bob: This is going to be hard.
Ms. Hughes: Maybe not. What's different about the liquids?
Mark: They're not the same color. One looks like cooking oil.
Aletia: They smell different. Is one syrup?
Sharon: Look what happens when you tilt the glasses. They move differently. The oil is definitely thicker than the water.
Mark: But what can we test? Color may make a difference.
Bob: I think it's thickness.
Aletia: How can we measure thickness of a liquid? We can check the color with the light probes.
Sharon: Yeah, let's do color.
Ms. Hughes: Do you all agree? What hypothesis will you test?
Aletia: The color of a liquid affects the sound it makes.
Bob: I still think it's thickness.
Mark: I'll go get the computer ready.

Similar discussions take place in other lab groups. Students agree on a hypothesis and then use the available resources to test their hypothesis.

Ms. Hughes: Let's hear what each group found.
Tomas: We chose temperature because the water glass felt cooler than the others. We used the temperature probe, but the temperature of the liquid in each glass was the same.
Sharon: Color had an effect. The darker syrup had a lower sound than the clear water. The cooking oil was in the middle.
Ms. Hughes: Several other groups did color. Did anyone find anything different?
John: We used the light probes. The graphs were different, but we can't figure out what they mean.
Marsha: We found something. The thickest liquid, we think it is syrup, had the deepest sound. It was lower than the cooking oil and the cooking oil had a deeper sound that the water.
Aletia: How can you measure thickness?
Marsha: We dropped a weight into each liquid and timed how long it took to sink. It took 1 second in water, 6 seconds in cooking oil, and 10 seconds in syrup.
Ms. Hughes: So, what's the answer? Color, temperature, or thickness?
Sandy: Temperature is out. But how can we choose between color and thickness? They both seem to make a difference.
Jack: You could put food coloring in water and see if there was a difference.
Ms. Hughes: That's an interesting suggestion. What would you expect to happen?
Jack: I'd guess that there wouldn't be a difference, but I don't know for sure.
Bob: I still think it has to be thickness.
Ms. Hughes: Why do you think that, Bob?
Bob: The thicker strings on my guitar make the lower notes, you know? So I figured it was the same way with the thickness of the liquids in the glasses.

After some more general discussion, the class agrees that the thickness of the liquids warrants further consideration. They decide to continue experimenting and Bob will bring in his guitar.

The examples presented in these three scenarios illustrate a few of the many possibilities for more constructive use of technology. Given time, resources, support, and structure, students and teachers are capable of much more than is possible with the traditional didactic mode of teaching/learning.

According to Kelly (1990), past educational reform efforts that stressed "the basics" focused heavily on rote learning and mechanical skills to improve standardized test performance at the expense of teaching higher-order thinking skills and abstract reasoning. Rote and mechanical skills are not, however, the types of experience that most well-paying jobs require of workers now or will require in the future. Students need opportunities to demonstrate their knowledge in ways that use information skills creatively. Technology-based activities offer many opportunities for students to reconstruct and produce knowledge in ways that have intrinsic value and will benefit them in their personal and professional lives.

Schools must evaluate and validate student learning. It is an educational truism that what gets tested gets taught: assessment drives the curriculum. By extension, *what* we teach often determines *how* we teach. Standardized tests cannot adequately measure outcomes in the three learning environments—interdisciplinary, cooperative, problem-centered—which have been discussed. Therefore, as noted by Thornburg (1991),

> restructuring the curriculum requires an immediate change in the nature and the content of assessment tools used to measure the effectiveness of programs (p. 99-100).

Authentic achievement must be more highly prized than the ability to fill in the correct bubble on a standardized form. It can be done, and **Section IV** presents some examples of activities which utilize classroom technology and instructional practices to promote authentic achievement.

Section 4

Examples of Learning Projects and Activities

- Tool Software
- Simulations
- Graphics Utilities
- Desktop Publishing
- Hypermedia
- Microcomputer-Based Labs
- Telecommunications
- CD-ROM
- Videodisc

EXAMPLES OF LEARNING PROJECTS AND ACTIVITIES

For several years, schools and teachers have had available a wide range of software that could bring major changes to what students do in classrooms and what they learn, but it constitutes only a minute portion of computer use in regular school subject classes.

H.J. Becker
When Power Tools Meet Conventional Beliefs and Institutional Constraints, 1991.

Computers and related technologies are unlikely to have a widespread impact on education unless they are effectively integrated into the objectives and activities of the classroom teacher. For this to occur, our expectations about what students can accomplish with technology must be expanded. Understanding requires more than just recalling facts, it requires using the content of instruction as the starting point—not the ending point—of knowledge.

Our expectations about what students can accomplish with technology must be expanded.

Thornburg (1991) proposes that the instructional environment of the future should "provide a non-linear multi-sensory interface to the natural learning styles of our students" (p. 34). What will students do in such an instructional environment? This section provides examples of projects and activities that suggest ways to utilize a variety of hardware and software within the context and content of restructured learning environments. The examples are presented to illustrate possibilities, not to describe full lesson plans.

Tool Software

Tool software (e.g., word processors, databases, spreadsheets) is rapidly becoming the dominant application of computers in schools. Like other classroom tools (e.g., pencils, paper, rulers, calculators, and typewriters), tool software helps students and teachers accomplish their tasks. The instructional emphasis is on the generation of products similar to those needed by businesses. Since tool software is flexible and content-independent, it can be integrated easily into a variety of subject areas.

Project: Stock Market Portfolio

Description: Select stocks for a model portfolio and monitor their performance for a month.

Activities:

(1) Students select shares of three or four stocks with a total value less than a prescribed amount (such as $10,000).

(2) Use newspaper or on-line service to find daily stock prices.

(continued)

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DYNAMITE IDEAS:

Multi-Media History

Students at Mountain Brook City Schools in Alabama have joined with the Birmingham Historical Society and Scholastic Publishing to produce a multi-media history of Birmingham. The result, "Making Iron: An Historic Tour of Birmingham," is being produced through a public/private partnership under the direction of Lakeside/SSA, Inc., a local educational consulting firm.

To create this product, children visited historic areas of the city, took photographs to be scanned and digitized, researched the sites, and wrote text links to accompany the photographs. Where appropriate, they added sound to the multimedia product.

In addition, a presentation entitled "Using Multi-Media in History Instruction" will detail the history project and focus on how Mountain Brook City Schools can organize a multimedia project, merge technologies to create media, and help children to combine research, reading, and writing skills in a production environment.

Contact:

Christine Drew
Lakeside/SSA, Inc.
9809 Jade Lake Road West
Pinson, AL 35126
(206) 681-0676

(3) Record daily share price in spreadsheet and calculate share values as well as individual stock and total portfolio profit/loss.
(4) Graph and print out data, showing results for the month.
(5) Using word processor, write narrative description of portfolio performance.

Simulations

A wide variety of events and phenomena that are too complicated, expensive, time consuming, or dangerous to conduct or replicate in a classroom can be simulated on a computer. The effect of changing conditions can be observed quickly and the results displayed in text, numeric, or graphic format.

Project: Frog Dissection

Description: Make an oral presentation about the components and function of a major body system in a frog.

Activities:

(1) Use a program such as "Operation: Frog"* to learn how to select instruments, probe and snip organs, and remove body parts.
(2) Have teams of students identify and remove the major organs of one body system (e.g., digestive, circulatory, respiratory).
(3) Re-assemble the frog correctly.
(4) Use information in the program and other resources to learn the function of each organ and the system.
(5) Have student teams give a presentation to the class on their system using the program displayed on a television or monitor as a visual aide.

*Programs of this type are available in many education software catalogs.

Graphics Utilities

Graphics and paint programs provide a new medium for artistic expression. From simple sign, banner, and calendar programs to sophisticated drawing and animation programs, graphics utilities provide artists of all skill levels with access to some very sophisticated tools. Images can be rotated, inverted, scaled, animated, or given three-dimensional representation. Completed images can be organized into slide shows and displayed for public view.

Project: Holiday Computer Art Show/Concert

Description: Use computer graphics software to create traditional scenes of holidays or other events for display in a computer art show.

(continued)

Activities:

(1) Use graphics software to "draw" a scene illustrating seasons, historical events, or holidays.
(2) Display the artwork publicly in printed form or on a computer slide show.
(3) Write simple programs to play music to accompany each picture, forming a computer concert.
(4) Transfer the images and music to videotapes for storage, etc.

Desktop Publishing

The advent of microcomputer desktop publishing has radically improved the quality of school reports and publications. Lunch menus, calendars, and report covers as well as newsletters, school newspapers, and yearbooks have been changed forever. The services of a custom print shop are no longer required. Desktop publishing programs can produce different fonts or type sizes and easily handle page layout and formatting options, digitization of scanned images, and laser printing.

The advent of microcomputer desktop publishing has radically improved the quality of school reports and publications.

Project: Community Almanac

Description: Create and publish an almanac describing unique aspects of your local community such as its history, government, population, environment, weather, organizations, and/or special events.

Activities:

(1) Conduct research on a selected topic.
(2) Synthesize research in narrative, tabular, or graphic format using word processing, database, spreadsheet, or graphic software.
(3) Design almanac with desktop publishing software.
(4) Sell business-card ads to pay for printing.
(5) Distribute through local chambers of commerce, libraries, banks, etc.

Hypermedia

Computers have freed information from the printed page. Hypermedia programs allow the creation of "stacks"—screens which contain or access text, images, video, and sound. Instead of moving through a pre-arranged sequence of information and images, stacks can be explored non-sequentially by clicking the mouse button when the cursor is on a button or icon. Peripherals such as videodisc and CD-ROM players can also be controlled.

Project: Whales

Description: Create a multimedia presentation about whales including their feeding habits, geographic distribution, reproduction, classification, and navigation.

(continued)

Activities:

(1) Conduct research on the topic.

(2) Synthesize research and organize for presentation in a hypermedia format.

(3) Assemble the stacks and create buttons to navigate through linkages.

(4) Interface with videodisc player to run appropriate segments of *National Geographic* videodisc on whales.

Microcomputer-Based Labs

In traditional labs, students apply the scientific method to a variety of "staged" lab experiments that may produce contradictory or meaningless results due to human error. MBLs (Microcomputer-Based Labs) collect and display data from sensors (e.g., temperature, light, voltage, resistance, etc.) that can be scaled, manipulated, and formatted in a variety of ways. MBLs allow students to concentrate on designing experiments and analyzing results rather than recording data and making complex calculations.

Project: Temperature vs. Surface Color

Description: Investigate the relation between the color of a material and the degree to which it absorbs light and converts it to heat.

Activities:

(1) Attach thermistor (temperature probe) to computer and perform any necessary calibration.

(2) Shine 100-watt bulb in a desk lamp on thermistor to produce a temperature of 100° F.

(3) Slip colored construction paper sleeves over thermistor one at a time and record the temperature once it stabilizes.

(4) Rank the colors from highest to lowest in order of light absorption and temperature.

(5) Discuss the relation between climate and the color of clothing. (Adapted from Becht, 1991).

Services offered by on-line information utilities include banking, shopping, investing, information retrieval, electronic mail, and conferencing.

Telecommunications

It is no longer necessary to hand-deliver information in every case. Telecommunications can be accomplished in a variety of ways. A simple method available to most schools is via a modem and phone line connecting two or more computers. Computer information that can be stored as a file (such as text, data, graphic images, and sound) can be exchanged among computers this way. Services offered by on-line information utilities include banking, shopping, investing, information retrieval, electronic mail, and conferencing.

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Project: Weather Report

Description: Create a "TV-like" weather report and forecast using computer-generated weather maps.

Activities:

(1) Develop an understanding of how to read and interpret weather maps.
(2) Download selected daily weather maps from CompuServe.
(3) Analyze and interpret the meteorological conditions depicted on the maps.
(4) Prepare a weather report and forecast to present to the class that includes maps displayed on the computer monitor.
(5) Compare the accuracy of the report and forecast to those made on TV or in the newspaper.

CD-ROM

CD-ROM (Compact Disc-Read Only Memory) discs are used to store large amounts of data that do not need to be changed often, such as directories, encyclopedias, abstracts, maps, and applications programs. CD-ROM is likely to change the way people search for and use information, and it will become increasingly important to teach students these new information retrieval skills. They will need to become skilled in formulating and executing search strategies to enhance their problem-solving skills.

Project: Electronic Research

Description: Conduct research for a report using CD-ROM reference materials.

Activities:

(1) Design and execute a search of a CD-ROM encyclopedia.
(2) Capture and save pertinent information on disk.
(3) Locate traditional print-based resources.
(4) Use word processor to write paper.
(5) Enhance with maps, clip art, or graphics from disk or CD-ROM.
(6) Assemble components in desktop publisher and print.

Videodisc

Videodiscs can store large amounts of high quality images and sounds. CAV (Constant Angular Velocity) discs are used for most educational applications and allow a wide range of special effects and interactivity. A remote control, bar code reader, or computer can quickly access any frame on the disc and play forward or backward at different speeds. Some of the most popular videodiscs being used in schools are content-specific archives of

DYNAMITE IDEAS:

TOUCHING TOMORROW TODAY

A collaborative effort among computer teacher, media specialist, principal, and district media director, Touching Tomorrow Today offers students at Southwestern Randolph Middle School state-of-the-art instructional technology. The program uses technology to model the workplace of tomorrow, take advantage of students' attraction to multi-media presentations, minimize record-keeping time, and enhance faculty communication.

Students can log on to networked computers, use a menu to retrieve and operate assigned instructional courseware, use a word processing program, and save their data on diskettes. Students can also locate information on a CD-ROM reference disc (encyclopedia, dictionary, and atlas), search for books in an on-line catalog, and check out books using an automated circulation system.

Teachers have access to a video retrieval system, laser disc player, video projector, poster-maker, CD-ROM reference discs, a scanner, and laser and/or color printers. They are also able to use technology for electronic grade books, word processing, on-line card cataloging, and accessing electronic bulletin boards. Administrators make use of phone message utilities, networked management information systems, word processing, electronic mail, and software designed to manage textbook inventories.

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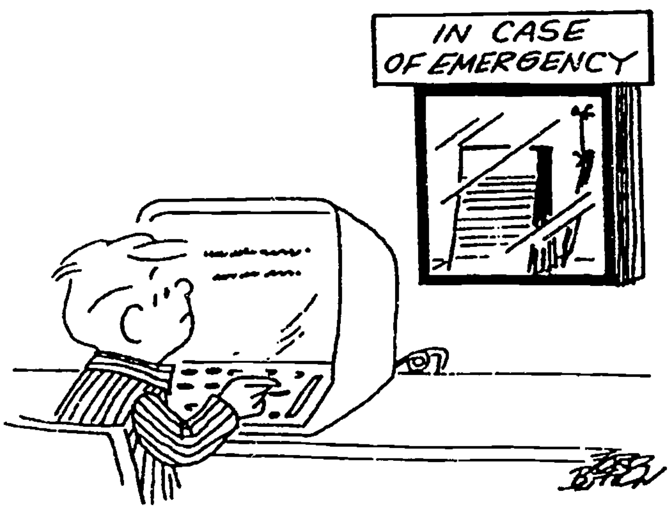
images and sounds (e.g., plants, animals, space, geology, meteorology, weather, art, and music). Each contains thousands of high quality images that can replace (or substitute for) large and expensive collections of books and slides.

Project: Video Report

Description: Make an oral presentation using an overhead data display and a videodisc.

Activities:

(1) Become familiar with the operation of an overhead data display for a computer and the use of presentation management software.
(2) Select an appropriate topic for which a videodisc is available (e.g., geology, meteorology, AIDS, etc.).
(3) Develop an oral presentation that will incorporate "computer slides" to highlight important points.
(4) Survey videodisc to become familiar with its contents and operation of the hardware.
(5) Locate useful still frames and footage on videodisc to accompany topics covered with "computer slides."
(6) Make oral presentation to class on selected topic using "computer slides" and images on videodisc.



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CONCLUSION

For computers to make a difference in how students experience schooling will require teachers and administrators to modify their concepts of appropriate and inappropriate teaching behaviors, to re-prioritize the value of different types of instructional content, and to change habits and assumptions that guide their classroom and school management strategies.

H. J. Becker
When Powerful Tools Meet Conventional Beliefs and Institutional Constraints, 1991

Many would agree that the Microcomputer Revolution has not transformed America's schools. Expectations that it would do so, however, were probably unrealistic because the amazing technical achievements of the last decade have been superimposed on an education system designed for another era and a different society.

It is no longer a question of what *should* we do, but rather what *must* we do to create schools for the 21st century? According to Branson (1990), there are two approaches to improving American education: (1) patch up the existing system or (2) design a new one. If so, the "patches" attempted to date appear to be reaching a point of diminishing returns, and calls for fundamental change are increasing.

Past educational reform efforts have had difficulty overcoming the inertia of educational tradition. But today, the convergence of three enabling initiatives—restructuring schools, expanding roles for teachers, and emphasizing authentic student achievement—with the catalyst of technology make the likelihood of achieving progressive change much more promising.

The future demands individuals who are technologically literate, critical thinkers, adept problem-solvers, able to access and organize information, capable of cooperative decision-making, and prepared to be life-long learners.

What do we want students to know and be able to do? The future demands individuals who are technologically literate, critical thinkers, adept problem-solvers, able to access and organize information, capable of cooperative decision-making, and prepared to be life-long learners. In the Information Age, "learning means the development of understanding, or the ability to perform complex cognitive tasks that require the active management of different types of knowledge around concrete problems" (Elmore, 1992, p. 45). Grade-level or subject-area content must be the starting point, not the ultimate goal, of instruction. More students must become actively engaged in the process of learning, rather than drifting passively through school. Thus, knowledge assessment measured by the ability to remember *the* right answer on a multiple-choice test can no longer drive instruction. Instead, learning how to learn and demonstrating authentic achievement must be the goals which guide effective instructional practices. How can teachers help students achieve these learning outcomes? Directed, didactic instruction, where the classroom is teacher-

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centered, must be de-emphasized. Student-centered classrooms which utilize constructivist teaching methods are more conducive to developing the skills required for authentic achievement and conceptual understanding. This approach, however, requires teachers to assume unfamiliar roles and new attitudes about teaching and learning. Teachers who want to practice non-traditional teaching methods may come into conflict with existing patterns of school organization (Elmore, 1992). Consequently, school organization must also be re-examined.

What kind of school organization supports these learning outcomes for students and new, expanded roles for teachers? At present, age grouping, classroom arrangement, teaching assignments, course offerings, and class size are largely determined by the school's organizational design. Thus, school organization also drives instruction. However, a new attitude is emerging: one that says structure "should enable teaching practices that are consistent with the objective of students' conceptual understanding" (Elmore, 1992, p. 47).

Technology of all kinds can be used to achieve each of these critical initiatives. The Council of Chief State School Officers has issued a policy statement regarding improving student performance through learning technologies that includes the following recommendations:

1. Develop a state plan for the use of technology in education.
2. Ensure the state, district, and schools have sufficient funding to initiate and sustain ongoing use of technology as articulated in the state plan.
3. Ensure students and school personnel have equitable access to technologies for their learning, teaching, and management styles.
4. Ensure educators have the staff support, training, time, authority, incentive, and resources necessary to use technology effectively.
5. Encourage the development and expansion of telecommunications networks.
6. Support the use of technology in student assessment to measure and report accumulated complex accomplishments and new student outcomes.
7. Develop national leadership for learning technologies.

(CCSSO, 1991: the full text of the policy statement appears in Appendix A.)

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These recommendations are generalized because different states are using technology to improve teaching and learning to various degrees and in various ways. Each state's plan will depend on its existing circumstances and needs, but the time has come to put comprehensive plans into action. The report concludes as follows:

> The potential for technological advances in support of teaching and learning seems limitless. Each new generation of computers, each advance in multi-media applications, and each gain in telecommunications delivery, such as fiber optic cable, opens more opportunities. "Information Age" realities seem close to the reach of some students, but the gap between current opportunity and actual use of technology in most schools is enormous (CCSSO, 1991, p. 6)

It has become increasingly obvious that any expenditure for technology must be leveraged with a greater investment in teachers. As Boe (1989) notes, "We bought huge quantities of technology for the revolution, but we neglected to train the troops" (p. 39). In the past, teachers have been taught how to *use*, but not how to *teach with*, computers. Renewed emphasis must be placed on both preservice and inservice technology education and training so teachers have the time, opportunity, and encouragement to revise their role in the technology-rich classroom.

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APPENDICES

A: Improving Student Performance through Learning Technologies: Policy Statement of the Council of Chief State School Officers

B: Florida Model School Consortia Act of 1985 and Florida's Model Technology Schools: Contact Information

Appendix A

IMPROVING STUDENT PERFORMANCE THROUGH LEARNING TECHNOLOGIES

Policy Statement of the Council of Chief State School Officers
November 11, 1991. Reprinted with permission.

(The Council of Chief State School Officers is a nationwide non-profit organization of the 57 public officials who head the departments of elementary and secondary education in every state, the District of Columbia, the Department of Defense Dependents Schools, and the five extra-state jurisdictions. Through its structure of committees and task forces, the Council responds to a broad range of concerns about education and provides leadership on major education issues.)

POTENTIAL

Learning technologies have an enormous capacity to support and advance restructuring of teaching and learning. Our nation must use technology's potential to improve elementary and secondary education performance and to provide all learners with the knowledge, skills, and experience necessary to be responsible and caring family members, productive workers, and informed global citizens.

"Learning technologies" encompass a wide range of equipment and applications which directly or indirectly affect student performance. Learning technologies range from a telephone which connects parents with teachers to a complex network of satellites, cables, and fiber optics which delivers interactive, multi-media learning opportunities. Technologies are tools. Their effectiveness as instruments of learning is not inherent; their power is derived from the teachers and students who use them. Their effectiveness is measured by whether they improve student performance and help students reach full potential.

Technologies offer information in a variety of formats—text, video, and audio—providing students an opportunity to use the medium most effective for their learning. Technologies enable teachers to focus their energies on coaching students with their individual growth because the general or standard transmission of information is done through the technologies. Teachers can give special attention to certain individuals without neglecting the progress of others who are successfully guiding their own learning. Technologies enable students to work individually or in small groups at their own pace, taking advantage of access to vast sources of information and working with complex connections among varied disciplines. Technologies stimulate students as active learners who control the pace and direction of content, questions, and responses.

Learning technologies can provide students and teachers equitable access to learning no matter the geographic location or fixed resources of the school. Telecommunications provide students and teachers with information resources of distant libraries, museums, and universities. Telecommunications offer courses, degree programs, and career development. They enable access to colleagues and specialists around the world and opportunities to connect student work with the problems and real work of other students and adults. Learning technologies expand the opportunities of teachers, students, and parents to connect learning activities in school with those in homes, community centers, and other institutions.

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The technologies of learning are the tools for productive, high-performance workers in the 21st century. In the "Information Age," the work force must be prepared to manage substantial amounts of information, analyze complicated situations for decision making, and react rapidly in a well-informed manner. Equitable availability of learning technologies is essential to assure all students are prepared to be adults with access to productive employment and community and political power. To keep up with the tools of the future work place and the technologies of the home, all students must have access to them and master their use.

Technologies are productive tools for teachers and administrators to use in automating record-keeping, student information and data for accountability. They help provide convenient and timely access to essential information on student outcomes, assisting teachers to tailor instructional programs to meet specific student needs.

STATE ACTION

Most states, districts and schools have successfully used some technologies to develop effective, exciting, and innovative learning environments. To stimulate systemic change and move beyond isolated model programs toward widespread integration of technology into learning, we must commit our efforts to strategies for these activities: planning at the state and local levels; funding; ensuring equitable access to technology; human resource training and support; expanding telecommunications networks; developing technology-based assessment tools; and establishing national leadership for learning technologies. To realize the potential for learning technologies states must take action, both individually and together, as stated in the following "Recommendations for Implementation."

States are at different stages in the development and use of learning technologies. Some have made bold moves or are ready to make a quantum leap in their actions. Many states have already completed steps such as those recommended below. Where bold actions have been taken, they are applauded as examples for other states to emulate. The comprehensive order of this paper in no way is intended to slow progress of any state to back-track or adjust its previous actions to the systemic approach suggested here. Quite the contrary, the intention is to encourage the leaders who have accomplished certain steps to maintain their leadership toward complete implementation.

The recommendations that follow provide guidance to a comprehensive approach to incorporate technologies at the center of teaching and learning. These are generic proposals intended for all states but not detailed to apply to any specific state. Each state must develop its own application, informed by this comprehensive design and cognizant that each of the components must be included in some form to assure a complete and effective state strategy.

RECOMMENDATIONS FOR IMPLEMENTATION

1. DEVELOP A STATE PLAN FOR THE USE OF TECHNOLOGY IN EDUCATION

States should establish a clear, long term strategic plan for learning technologies. The plan should provide a vision of technology's role in education services, propose effective use of funds, ensure equitable access to technology, and maximize connections among technologies.

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Provide a state vision of technology's role in education. The state must communicate a clear and persuasive vision of technology's role in education to ensure that all key persons—the governor, legislators, state education agency staff, higher education authorities, school board members, administrators, teachers, parents, and students—work toward a common goal of using technology.

Include these key components in state and local plans. Plans should include an identification of needs; clearly defined goals and objectives; an evaluation of each selected technology's capabilities and cost-effectiveness; a description of the governance structure and systems operation; a delineation of current and future funding sources; a strategy for teacher, administrative, and support staff training; an evaluation plan; a strategy and schedule for implementing the plan; procedures for assisting local education agencies in the development of local technology plans; and a mechanism for modifying the plan itself. Planning is an ongoing process and plans should be continually re-evaluated based on program outcomes, analysis of program effectiveness, new research, and technology development.

Outline the responsibilities at the state, district, and building levels to ensure the technology plan is developed and implemented successfully. Each state should determine the planning process which best fits its needs; there is no single planning process for all states. With the trend towards site-based decision making, districts and schools are increasingly responsible for planning and implementing technology programs to meet their specific needs. At the same time, the economies of scale derived from aggregate purchases and the use of telecommunications networks for large scale delivery drive planning to higher levels within and among states.

While specific responsibilities vary by state, educators from different levels of the state's education system should participate in planning to achieve full integration of technology into education and to assure clarity of responsibility and action at each level. Technology plans at each level should be developed by teams which include financial and policy decision makers, teacher and administrator representatives, post-secondary and higher education representatives, technical experts, individuals with experience in curriculum development, instructional management, and assessment, and other major stakeholders in education.

Ensure that plans for other programs within state education agencies incorporate the use of appropriate technology. State education agency plans for the several state and federal programs should incorporate the use of appropriate technology to ensure that technology is effectively integrated into each state education service and across the services.

Share the state vision and plan with other state agencies.

2. **ENSURE THE STATE, DISTRICTS, AND SCHOOLS HAVE SUFFICIENT FUNDING TO INITIATE AND SUSTAIN ONGOING USE OF TECHNOLOGY AS ARTICULATED IN THE STATE PLAN.**

Develop a bold new plan to provide steady funding for learning technologies. Technology is an integral part of education; consequently, the federal, state, and local governments are responsible for providing funds to initiate and sustain the use of educational technology.

Funding should cover all costs associated with the technology and the necessary support for continuing effective use, such as training, maintenance, and upgrades. Avenues to decrease the cost of technology

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by aggregating purchases across the nation, state, or regions should be developed to the full extent. To supplement federal, state, and local funds, alternative funding options, such as business-state partnerships and foundation grants, should also be pursued.

Initiate state development of learning technologies. States are in a unique position to stimulate and initiate development of learning technology products. States should use the opportunity to undertake cost-effective projects in technology which support the state's curriculum frameworks and education goals.

Include expenditures for technology as part of capital outlay. Investments in educational technology should be considered capital expenditures which may be depreciated over the life of the product.

3. ENSURE STUDENTS AND SCHOOL PERSONNEL HAVE EQUITABLE ACCESS TO TECHNOLOGIES FOR THEIR LEARNING, TEACHING, AND MANAGEMENT NEEDS.

Equitable access must be addressed at the national, state, district, and school-building levels. Access must be provided to current technologies and to fully interactive information networks which transfer voice, video and data.

Federal and state policies should assure access to technologies for learning. Many current federal and state policies which were developed prior to the introduction of new technology in education were designed for application solely to the traditional classroom environment. Such policies may now be limiting access to technology, and, therefore, it is imperative to review them to assure currency and equitable access. The following issues are especially important for policy review and update:

Cost of access: To ensure that students and school personnel have "affordable" access to technology and information networks, it is necessary for technology providers to establish rates and other policies specifically for educational purposes. What is "affordable" for education may not be what is "affordable" for profit-making corporations. For example, state public utility commissions and the Federal Communications Commission should establish special telephone rates for education with the objective that rates be low enough to enable students and school personnel to take advantage of the voice, video, and data services transmitted over the telecommunications systems. The rates must be sufficient to ensure continued investment in development of future applications for the education market. Telecommunications costs should be equitable regardless of the factor of geographic location.

Information access: Intellectual property and copyright laws must be revised toward the objective of increasing student and school personnel access to information and the flexibility to use the information for instructional purposes while ensuring that the owners and originators receive adequate recognition and financial reward. These laws and other policies should encourage development of information sources which are electronically accessible.

School facilities design: School facility design requirements, whether for new schools or for building rehabilitation, must support the use of learning technologies. Electrical outlets and voice, video, and data lines are critical components of the modern school. The school facilities must be designed to support new instructional strategies which use technology (e.g., individual or small group learning, varied workstations).

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Use of federal and state funds: Federal and state policies should authorize purchase of learning technologies with funds currently earmarked for textbooks, instructional materials, and learning resources.

Provide access to learning technologies both inside and outside the school building just as access to textbooks is provided both inside and outside school. To compensate for unequal technology resources in the home and among schools, extra effort must be made by states, districts, and schools to provide all students access to learning technologies both in and outside school buildings. Schools should establish programs to loan equipment to students and school personnel for home use. Schools, libraries and other information sources should make their resources accessible during extended or non-school hours.

4. ENSURE EDUCATORS HAVE THE STAFF SUPPORT, TRAINING, TIME, AUTHORITY, INCENTIVE, AND RESOURCES NECESSARY TO USE TECHNOLOGY EFFECTIVELY.

Encourage local districts and schools to develop "technology teams." To effectively integrate technology into the classroom, teachers need to work closely with strong support teams which include principals, library media specialists, technicians, and other support staff. Technology teams should include individuals with decision-making authority and expertise in technology, curriculum design, instructional design, and student assessment. Technology teams should provide teachers with technical support to keep equipment operating, inform them on emerging technologies and programs, suggest ways to renew the curriculum through technology, and assist in assessing the outcomes of the learning technologies.

Ensure professional development activities to fully integrate technology into schools. States must provide rigorous continuous training to ensure all educators develop the skills necessary to use technology in their work. Ongoing professional development activities should be offered cooperatively by states, local districts, and vendors to provide timely training with technology purchases and upgrades.

As learning technologies become more powerful and complex, teachers must increase their capacities to use technology. Teachers must learn how to operate available equipment and applications, evaluate the potential of instructional applications, integrate the technology into the curriculum, use technology for administrative and assessment purposes, and, hopefully, develop a willingness to experiment with technology. They must receive training to develop the group management, decision-making, and coaching skills necessary to help students use technology effectively.

State and local education agency staff must be trained for understand to technology's potential as an instructional, administrative, and assessment tool and stimulated to experiment with technology-based programs.

State education agency staff must join with higher education authorities to assure licensure requirements lead to professionals who will use technology effectively in the learning environment. They must also create incentives to encourage professional commitment to technology.

Provide time, authority, incentives, and resources necessary to use learning technologies. The integration of learning technologies at the center of teaching and learning requires substantial changes from the practice of the traditional classroom. Many of the changes pertain to the role of teachers—their use of time, incentives, relationships with colleagues, and resources available to them.

Educators must have convenient access to a wide range of technologies in their schools, classrooms, and homes. These include the technologies of the contemporary work place of other professionals and specialized learning technologies. The more opportunity educators have to become comfortable with and competent with technology, the more likely they are to use it in teaching.

Use of learning technologies may require substantially different class schedules, class length, and class sizes. Such changes cannot be made in isolation but must be part of decisions which authorize different arrangements for cooperation and logistics.

Evaluation criteria and processes for teachers must ensure they are judged effectively in the use of technology and are encouraged to use it. Current criteria and processes may effectively penalize teachers who use technology. For example, if the criteria is to require a teacher to "deliver" instruction, the teacher who coaches the students to use technology for "delivery" may be penalized.

5. ENCOURAGE THE DEVELOPMENT AND EXPANSION OF TELECOMMUNICATIONS NETWORKS.

State, inter-state, national, and international telecommunications networks are critical to provide students and educators equitable access to resources outside the school and establish connections between the school and the home, community, and outside resources.

Plan, fund, and build telecommunications networks. Governors and state legislators, the President and Congress are encouraged to provide support for coordination and expansion of current telecommunications networks and develop new statewide, inter-state, national, and international telecommunications networks to serve education.

Advocate national standards to increase connections among and use of voice, data, and wide-band video networks. Telecomputing networks should operate as national, non-proprietary standard telephone networks do. A telephone user can communicate with another user regardless of which telephone companies provide the services. A routing system is needed to communicate across telecomputing networks; national standards and policies for telecommunications are needed to assure the networks serve education.

To expand distance learning and ensure it meets acceptable standards, multi-state cooperative agreements are necessary for teacher qualifications and course specifications. Varying state requirements for certification and course approval currently require teachers of distance learning to meet multiple state certification and course approval requirements. In some cases, teachers are required to take physical exams and demonstrate knowledge of the state's history and government, even though they are not teaching that subject. To assure standards of good quality for teachers are set in a manner which enables expansion of distance learning, multi-state cooperative agreements are needed.

Multi-state agreements on the standards for the courses to be offered by distance learning are also needed to assure effective expansion of student opportunity to learn.

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6. SUPPORT THE USE OF TECHNOLOGY IN STUDENT ASSESSMENT TO MEASURE AND REPORT ACCUMULATED COMPLEX ACCOMPLISHMENTS AND NEW STUDENT OUTCOMES.

Learning technologies offer valuable contributions to strengthen teaching and learning of critical thinking and problem solving and to measure these capacities. Technology-based assessments can contribute to many aspects of student performance testing including the following: clear statement of multiple student outcomes; measurement of complex indicators of student learning; collection of data; management of information in such forms as portfolios; and analysis, processing, and timely reporting of testing.

The effective development of technology for student assessment should be encouraged through collaboration among the states, working with key stakeholders at national and local levels.

7. DEVELOP NATIONAL LEADERSHIP FOR LEARNING TECHNOLOGIES.

The federal government should establish leadership in learning technologies. The federal government should institute processes to develop a coordinated vision for the effective use of technology in education. This vision should be based on the reports of the Office of Technology Assessment, *Power On!* and *Linking for Learning*. Federal leadership is essential to the nation's efforts in research and development to provide direction in the development of the national telecommunications infrastructure and to ensure that all federal education programs incorporate use of technologies as summarized below.

Ensure the federal government provides increased investment in research and development of learning technologies. To realize the full potential of learning technologies, systematic research must be conducted on how students learn, the capabilities of current and emerging technologies, and the impact of technologies on student outcomes and the learning environment.

A national research agenda related to technology in education must be developed collaboratively by state, local, and federal education agencies. The federal government should have the primary role in providing increased and consistent funding for research and development of learning technologies and instructional strategies.

The federal government should take leadership in the rapid establishment of an infrastructure to support learning technologies. The use of learning technologies across the nation requires the federal government's leadership in establishing an infrastructure which includes fiber optic cable and other carriers to transmit all signals throughout the nation. The infrastructure must have the capacity for all signals including telephone calls, data transmission, fax, graphics, animation, compressed television, full motion television, and high definition television.

Assure the transfer of technologies from federal agencies to state and local education agencies. The Department of Education should lead an effort to identify and disseminate learning technologies developed and used by the Departments of Defense, Energy, and Commerce, and by other federal agencies. The federal investment in learning technologies in such agencies is far more extensive than in the Department of Education. State and local educational systems need access to it through a coordinated dissemination program.

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CCSSO and other national education organizations should increase advocacy for education's technology needs at the national level. Federal policies and actions on learning technologies are critical to the availability of such technology at the state and local levels. CCSSO and other national education organizations must increase their efforts of advocacy to assure federal telecommunications and technology decisions support improvement of teaching and learning. Strong representations need to be made to the President; Congress; the federal courts; the Federal Communications Commission; and the Departments of Education, Commerce, and Agriculture. Specifically, CCSSO should continue to take positions on learning technologies authorizations, appropriations, and legislation which impact the national information infrastructure and education's access, as it has on the recent legislation and court rulings concerning the Bell Operating Companies' right to manufacture telecommunications equipment and provide information services. As Congress debates future actions concerning such issues as cable interconnectivity, spectrum allocation debates, and intellectual property rights, CCSSO should represent educational concerns.

CONCLUSION

The potential for technological advances in support of teaching and learning seems limitless. Each new generation of computers, each advance in multi-media applications, and each gain in telecommunications delivery, such as fiber optic cable, opens more opportunities. "Information Age" realities seem close to the reach of some students, but the gap between current opportunity and actual use of technology in most schools is enormous.

We hope this paper captures a vision of opportunities that learning technologies might provide for all. This vision will keep changing as invention follows new paths of technological creation. The vision will help us only if the states and our nation take the steps recommended here to bring the next generation's tools to the hands and minds of our students. The Council of Chief State School Officers is committed to bring the vision and recommendations here to reality for all American Students.

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Appendix B

FLORIDA MODEL SCHOOL CONSORTIA ACT OF 1985

(1) SHORT TITLE--This section may be cited as the "Florida Model School Consortia Act of 1985."

(2) LEGISLATIVE INTENT--The Legislature recognizes that the public school system would be strengthened by the establishment of one or more secondary or elementary schools operating as prototype technology schools throughout Florida, supported by public-private consortia. The Legislature is further aware of the links between education, training, and economic growth and of the need for increasing technical and analytical skill levels of the future work force. The schools, through combining new technologies and training supplied by the private sector throughout the curriculum and administration, shall promote educational productivity and knowledge of students and teachers in the classrooms.

(3) STATEWIDE PLAN--

(a) The Commissioner of Education shall develop a statewide comprehensive plan for the establishment of prototype technology schools. In developing the plan, the Commissioner shall consult with a planning group to consist of representatives from business and industry, the Florida High Technology and Industrial Council, the Academy of Sciences, state community colleges and state universities, vocational education, teaching organizations, school district personnel, the Executive Office of the Governor, the Legislative, and parents. Legislative representation shall be one member of the Senate appointed by the President of the Senate and one member of the House of Representatives. There shall be regularly announced meetings, and the Commissioner, or his or her designee, shall serve as chairman of the planning group.

(b) The comprehensive plan shall include, but not be limited to, a framework and guidance for the establishment of a model school. The plan shall recommend:

1. Criteria for the establishment of a model school.
2. The governance structure of a model school.
3. Preconditions for site selection and acquisition for the location of a model school.
4. Funding mechanisms and proposed start-up budget for a model school.
5. Methods for acquiring non-state funds to help support and operate a model school.
6. Stipulations for the acceptance of donations of funds, professional services, equipment, buildings, and sites for model schools.
7. Broad educational specifications for model schools.
8. Opportunities for training experiences for potential and practicing public school teachers in a model school.
9. Distribution of successful practices and techniques used in the model schools to the public school system.

(c) The State Board of Education shall adopt the comprehensive plan, and the commissioner shall submit it to the appropriate offices of the Legislature by or before February 15, 1986, for funding.

(d) A designated school shall be administered by a local model school board of trustees. Each model school shall be established as a nonprofit organization which shall meet specified educational standards and criteria established by the approved comprehensive plan and shall contain a representative population of students who attend public schools in the district in which the school is located. No student is to be charged attendance fees, and the state and the district in which the school is located shall place annually into the state trust fund, or a designated model school trust fund, the appropriate amount of FTE funding that corresponds to the model school student population. These funds may be matched by grants and donations and shall be distributed to designated model schools.

(4) ESTABLISHMENT OF THE TRUST FUND--There is hereby established a Trust Fund for the Model School Consortia to be administered by the Department of Education. The Legislature shall designate funds to be transferred to the trust fund from the General Revenue Fund Donations and grant funds may be accepted, and all funds deposited into the trust fund may be invested pursuant to the provisions of s. 18.125. Interest accruing to the trust fund shall increase the total funds available.

Florida's Model Technology Schools: Contact Information

Webster Elementary School
420 N. Orange Street
St. Augustine, FL 32095
(905) 824-2955
(fax) 829-5958

Principal: Roger Coffee
MTS Facilitator:
Cathy Hutchins

Chamberlain High School
9401 N. Boulevard
Tampa, FL 33612
(813) 932-6141
(fax) 935-2373

Principal: James S. Gatlin
MTS Facilitator: Larry E. Nanns

John I. Leonard Community High School
4701 10th Avenue North
Lake Worth, FL 33460
(407) 641-1231
(fax) 642-1006

Principal: Luke Thornton
Assistant Principal/
MTS Facilitator: Jim Sheehan

L. D. McArthur Elementary School
330 East Ten Mile Road
Pensacola, FL 32534
(904) 484-5115

Principal: Martha B. Lyle
MTS Facilitator:
Barbara Holifield

Mainland Senior High School
125 S. Clyde Morris Boulevard
Daytona Beach, FL 32114
(904) 252-0401
(fax) 252-0359

Principal: Tim Huth
MTS Facilitator: Marshall Ransom

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