DOCUMENT RESUME

ED 330 249 HE 024 325

TITLE	Technology and the Future of Education: Directions for Progress. A Report of the California Postsecondary Education Commission's Policy Task Force on Educational Technology. Report 89-27.
INSTITUTION	California State Postsecondary Education Commission, Sacramento.
PUB DATE	Sep 89
NOTE	58p.
AVAILABLE FROM	Publications Office of the Commission, 1020 Twelfth Street, Third Floor, Sacramento, CA 95814-3985.
PUB TYPE	Information Analyses (070) -- Viewpoints (Opinion/Position Papers, Essays, etc.) (120)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Agency Cooperation; Educational Planning; *Educational Technology; Elementary Secondary Education; Financial Support; *Futures (of Society); *Higher Education; Instructional Improvement; Long Range Planning; State Colleges; State Universities; Technological Advancement; *Technology Transfer
IDENTIFIERS	*California

ABSTRACT

This report discusses a plan for more effective use of new technologies in California higher education, including their coordination, financing, quality control, and incentives. The report begins with an examination of the potential that new technology has for revitalizing educational practices and alleviating some of education's persistent problems. Early sections describe current applications and list goals for the immediate future. Next, the report discusses the need to articulate a vision of the future and identify the obstacles to achieving that vision. Finally, the report explains the need for a range of agencies and organizations to cooperate in making possible an equitable distribution of the educational benefits of the new technologies. Fourteen recommendations are included, among them: (1) that there should be a mechanism for intersegmental coordination and planning of informational technology; (2) that schools and campuses should be provided with additional resources for giving teachers technological training; (3) that the Governor and/or Legislature should establish a forum through which the State government, the educational community, and members of business and industry could jointly encourage the use of technology at all levels of education; and (4) that the Legislature and the educational institutions should expand the use of distance education technologies to ensure that no student anywhere in the State is denied access to high quality instruction in a full range of subject areas. The appendix contains brief descriptions of those technologies (computers and telecommunications) currently being applied to educational uses. Contains 15 references. (GLR)

Summary

This report is the product of the Task Force on Educational Technology -- a 19-member group of educators, corporate representatives, and state officials that the California Postsecondary Education Commission established in 1988 to develop a plan for more effective use of new technologies in California higher education, including their coordination, financing, quality control, and incentives. Although the Commission convened the Task Force, it viewed the group as a policy body that should develop an independent report.

The task force undertook its work during 1988-89 with several presuppositions -- that (1) technology has the potential to revitalize educational practices and alleviate some of education's persistent problems; (2) some vision of the future must be articulated and obstacles to achieving that future must be identified; and (3) a range of agencies and organizations must cooperate in making possible an equitable distribution of the educational benefits of the new technologies.

The structure of the report derives in general from this division of the topic. Early sections on pages 5-30 describe current applications and list goals for the immediate future; some of the major barriers to be overcome are discussed on pages 31-36; and recommendations begin on page 37. The Appendix on pages 43-49 contains brief descriptions of those technologies currently being applied to educational uses.

The Postsecondary Education Commission endorsed this report at its meeting on September 18, 1989, and herewith acknowledges with gratitude the efforts of the task force in preparing the document. Additional copies of the reports may be obtained from the Publications Office of the Commission at (916) 322-4991. Questions about the substance of the report may be directed to Norman Charles, the Commission's Assistant Director for Educational Policy, at (916) 322-8020 or to Bruce Hamlett, the Commission's Director of Legislative Affairs and Budget Analysis, at (916) 322-8010.

Cover drawing courtesy *Academic Computing*, Volume 2, Number 5 (February 1988). Permission to reprint granted by Academic Computing Publications, Inc.

TECHNOLOGY AND THE FUTURE OF EDUCATION

Directions for Progress

A Report of the California Postsecondary Education Commission's Policy Task Force on Educational Technology

CALIFORNIA POSTSECONDARY EDUCATION COMMISSION
Third Floor • 1020 Twelfth Street • Sacramento, California 95814-3985

COMMISSION REPORT 89-27
PUBLISHED SEPTEMBER 1989

Contents

Introduction

WHEN future historians of education discuss the significance of the 1980s, they will have to take into account at least two occurrences during the decade: (1) the steady stream of books and reports that pointed with alarm to the shortcomings of America's schools and colleges; and (2) the emergence of the new information technologies as vital tools for teaching and learning at all educational levels.

This report grew from a conviction that the imaginative use of technology can have a major impact on the quality and effectiveness of instruction in every subject; that it can contribute to the solution of several of education's most refractory problems; and that a concerted effort to plan for and coordinate its integration into the educational process is now essential.

This report is by no means alone in calling attention to the potential contribution of technology to teaching and learning. A number of recent publications have stressed this theme:

- *Power On: New Tools for Teaching and Learning* (1988), by the U.S. Congress' Office of Technology Assessment, thoroughly documents the use of technology in the nation's elementary and secondary schools. It tackles such issues surrounding the use of technology in education as cost effectiveness, the role of the teacher, business and marketing aspects, and research and development, and claims that if the present level of enthusiasm for educational technology is sustained, it may prove to be a principal catalyst of school improvement (p. 189).

- *National Education Association Report on Technology* (1989), issued at NEA's annual meeting in July 1989, calls for systematic computer training for teachers and a computer on every teacher's desk by 1991.

- *Vision: California 2010* -- a report of the California Economic Development Corporation (1988) -- calls for a major restructuring of the goals, curriculum, instruction, and productivity of the educational system. It argues that the restructuring of instruction will require a richer mix of instructional techniques and technology tailored to different students (p. 26).

- *Restructuring California Education: Recommendations to the California Business Roundtable* (1988), by Berman, Weiler Associates, focuses on school reform issues, such as school-based management, schools of choice, and curricular reform, and identifies technology as a way to implement widespread curricular improvements. It recommends a comprehensive program to insure that all schools can use computer-based technology effectively and calls for State standards for technology purchase and use, State incentive grants for staff training, better use of resources, the formation of consortia of schools, and a broad range of other proposals for integrating technology into the schools.

- *Strategic Direction for Information Technology in California State Government, 1988-1990* (1988), by the Office of Information Technology, focuses more on the technology needs of the bureaucracy than those specifically of education, but nevertheless issues a forceful call to equip "knowledge workers" within the State with efficient electronic access to the information they require through networks and interconnections that will allow any State work station to transfer information to any other State work station.

- *The Master Plan Renewed* (1987), by the Commission for Review of the Master Plan for Higher Education, notes that the new instructional technologies have the potential for revolutionizing the educational process and recommends that each segment of California higher education establish appropriate infrastructures so that the new technologies are effectively integrated in support of institutional missions. It also recommends that the California State University have a special responsibility to investigate and evaluate the effect of technologies on the learning process.

- *Education Offered via Telecommunications* (1987), by the California Postsecondary Education Commission, concluded that "In order to utilize effectively the potential of the new technologies . . . while also containing the long-run costs to the State . . . it is imperative that statewide planning be initiated for these technologies" (p. 12).

In the fall of 1988, the Commission began two projects which laid the groundwork for this report, one project to deal with the topic of educational telecommunications, and the other directed toward issues related to the computer in education. When it proved impractical to keep these topics separated, the two projects were merged and their respective advisory committees were consolidated into the Policy Task Force on Educational Technology. The three-fold mission of the Task Force was to

(1) project a vision of the future in the form of goals and principles for integrating technology into education; (2) review the current scene and identify promising applications as well as barriers impeding progress; and (3) propose measures designed to achieve the goals.

The members of the task force recognize the need for some tentativeness in making conclusions and recommendations on a subject that is evolving so rapidly that much of what was written four or five years ago is now seriously outdated. But the task force also recognizes that the tremendous population growth in California, crisis-level deficiencies in portions of the state's educational program, the changing demographics and economic structures of the State and the region, and the demands for a well-educated and capable workforce make the issuance of this report timely and necessary. Technology alone cannot be counted on to resolve these concerns, but it can assist educators in meeting the critical needs identified in so many of this decade's education reform reports. As a potential catalyst for major systemic change and for the implementation of new educational structures and approaches, technology applied to education is now sufficiently powerful that its demands, risks, possibilities and consequences must be directly identified and confronted.

In this report, the task force argues that technology is changing the process of education permanently and profoundly, and it recommends actions at the State and other levels to ensure that the application of technology to education occurs in a timely, orderly, and efficient manner and that its educational and economic benefits are distributed evenly to all citizens of the State.

Members of the Task Force

Craig Blurton, Director, California Technology Project

Norman Charles, Assistant Director, Educational Policy
California Postsecondary Education Commission

John Cradler, Director of Project Development
San Mateo County Office of Education

Bruce D. Hamlett, Director, Legislative Affairs and Budget Analysis
California Postsecondary Education Commission

William Hamre, Associate Vice Chancellor
California Community Colleges

Cathy Hudson, Head, Library Automation Office
California State Library

David Leveille, Director, Institutional Relations
Office of the Chancellor, The California State University

Donald Lloyd, Marketing Manager, Hayes Microcomputer Products

Allen G. Marr, Dean, Graduate Studies and Research
University of California, Davis

Brenda McChesney, Education Market Manager, Pacific Bell

Donovan Merck, Director, Office of Technology
California State Department of Education

Barbara O'Connor, Chair, Educational Technology Committee,
and Professor, Department of Communications
California State University, Sacramento

Saul Rockman, Manager, K-12 Education Research and Evaluation,
Apple Computer

Joan Schaefer, Discipline Coordinator, Computer Information Systems
Southwestern College

Jill Shinkle, Research Assistant
California Postsecondary Education Commission

Dennis E. Smith, Director, Library Affairs
Office of the President, University of California

Beth Ullman, Regional Manager, University Programs, AT&T

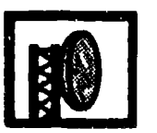
Frank Wallace, Consultant, Office of Educational Technology
California State Department of Education

Richard West, Assistant Vice President, Information Systems
Office of the President, University of California

Thomas West, Director, Computing and Communications Resources
Office of the Chancellor, The California State University

John Witherspoon, Director, Center for Communications
San Diego State University

Robert Wyman, President, The Wyman Group, and
Executive Director, North California Telecommunications Consortium



1 The Promise of Technology

An Opportunity for Change

The Final Report of the California Legislature's Joint Committee for the Review of the Master Plan for Higher Education is inspired by the vision of California as a "fully multicultural democracy, in which persons of all races and ethnic origin have full opportunity, in which all are empowered to participate as equal citizens" (1989, p. i). The Joint Committee believes an education for a multicultural democracy means an education for everyone -- to the full extent of his or her capacities and inspirations. Thus,

> we seek an educational system which imaginatively insures that the full benefits of learning are available to persons now on the margins. We want programs of outreach and encouragement which move beyond the formality of 'opportunity' to insure the access and success of all students. We want opportunity backed up with programs and resources (p. 5).

This challenge from the Legislature has come at a propitious time in the evolution of educational practices. It is a time when technology is vastly extending the variety of ways we can teach and learn. New uses of technology in the classroom are being reported daily, with benefits to students of every description. The computer, telecommunications media, laserdisks, computer compact disks (CD-ROM), and various combinations of these and other technologies -- which are described in the Appendix and referred to in aggregate throughout the document as "information technology" or "educational technology" -- offer unprecedented opportunities for enhanced learning. The effective use of these technologies allows students to access and manipulate collections of data, pictures, or sound; to observe real-world phenomena that would be difficult or impossible to observe in real life or in the laboratory; to decide at what level of difficulty to become involved with a given subject and to receive computer-based coaching and practice; to gain experiences that will be useful in the increasingly high-tech working world; and, for those who are far removed from the physical classroom, to be able to participate as if they were there. In these and other ways, the new technologies can alleviate barriers of distance, disability, language, age, and economic condition. By providing a sense of increased personal power and by incorporating a spirit of play and discovery, they can also

enliven the classroom experience for everyone, but most importantly for those whose interests are not now being engaged by traditional methods of instruction.

Technology and Educational Equity

The opportunity to use technology in education is not available equally to students throughout the State. A wide disparity in technological sophistication exists among schools. In an economy and society that is characterized increasingly as "information-based," opportunities to benefit from the improved instruction made possible by technology, and to learn about technology and its relationship to the working world are critical needs of every student. Yet a nationwide assessment of student's computer competence found that white students have a clear advantage over Black and Hispanic students across grade levels, and that students who attend private schools demonstrate a higher degree of computer competence than those in public schools (Martinez and Mead, pp. 47, 55). These findings are disturbing and point toward what many educators feared might result from the introduction of information technology into the home and classroom: increased polarization between the educationally advantaged and disadvantaged.

If the introduction of technology into our educational institutions were to occur broadly and equitably, instead of increasing disparity, technology could serve as an equalizer, as a neutral tool, and as a medium to accommodate individual students' distinctive interests and abilities. Already the new technologies when used properly have proven effective in motivating students, facilitating inquiry, improving students' writing, reaching students in remote sites, and raising the quality of instruction in many subject areas. Well-designed instructional software and other new technology tools will provide additional opportunities for instructors to focus attention on the individual as well as on the class. Before long, vast amounts of information on any topic will be available on-line -- in the form of text, data, photos, drawings, clips of film or pieces of music -- and students, teachers, and administrators will be able to explore information of interest, quickly moving through the morass to find what is needed and freely exploring related items. Electronic publishing promises to become an additional means of equalizing all students' access to information. As the current educational benefits of technology continue to develop -- spurred by increases in the sophistication of the technology and increases in the understanding of its proper

application to education -- it is critical that these benefits be shared equally and that existing inequities not be heightened.

The Age of Information

In a broader sense, more is at stake than possible innovations in classroom practices. As Warren Bryan Martin of the Carnegie Commission for the Advancement of Teaching put it, we are not dealing with a change of technology like the change from the icebox to the refrigerator. "We're talking about tools so powerful, with such marvelous speed, capacity, and resourcefulness, they are significantly changing society and may be indeed leading to its transformation -- radically amplifying the work of our minds" (DeLoughry, 1989, p. A15). We are experiencing the onset of the Age of Information in which "knowledge workers" will dominate the workforce, more and more careers will require the ability to manipulate information, and the context for policy decisions will become increasingly global because the world is connected electronically. Virtually limitless data will be instantly available to those who know how to access and use it. These individuals will be the productive participants in a multicultural democracy. Those unable to access and use it are almost certain to remain socially and economically dependent.

Education and the Workforce of the Twenty-First Century

Can the educational system adapt rapidly enough to meet changing needs of the American workforce of the twenty-first century? In *Building a Quality Workforce*, the federal Departments of Education, Labor, and Commerce project an economy increasingly reliant on information as a commodity and the need for a much more skilled general workforce. Most employers in their survey felt that competencies of entry-level workers are currently deficient for jobs in the information age, raising concerns that the nation's economic well-being may be threatened by an inadequately prepared workforce in an increasingly complex work world. The Office of Technology Assessment of Congress makes the point that our schools are not developing technologically as quickly as are other segments of our society: "... the chasm in technological sophistication between our schools and the environment in which students will work gives pause" (Office of Technology Assessment, U.S. Congress, 1988, p. 187.

Importance of Early Opportunities

All citizens have a stake in insuring that young people, especially those "now on the margins," have a reasonable chance to prepare themselves for life in the information age. A great deal depends on how effectively the educational system can integrate technology into the learning process.

The tools of the new technologies not only enhance learning, they must themselves become the object of study as tools to learn to use. It seems likely that some experience with the computer will soon be expected for even many entry level jobs; almost certainly persons without such experience will find fewer and fewer opportunities for advancement. Schools therefore have an obligation to introduce all students, not only the college bound, to the new information technologies.

At the collegiate level, the impact of technology is being felt across the curriculum. The concepts, materials, and modes of inquiry in all fields of study, from classics to cognitive science, will be altered significantly. In the sciences, computers will become "the dominant method for investigating many kinds of systems. . . . There will be very few scientists in 2000 who do not spend the majority of their time in front of their computers" (Young, 1988). In the humanities and performing arts, technology has already transformed musical composition and stage production and design, for example, and is opening new possibilities for the study of art and architecture, language and literature, history and culture.

In such an environment, there exists the grave potential that students who have not developed a comfortable familiarity with the tools of technology will be increasingly handicapped. As noted earlier, current disparities in student achievement and performance levels are in danger of being heightened by still another variable -- degree of access to technology in the earlier grades. All of California's public institutions of education bear the joint responsibility of ensuring equity of access to the necessary technologial tools at each grade level.

Technology's Potential for Solving Critical Educational Problems

The demonstrated potential of technology requires that it be used to transform the educational experience of California's neediest students and to meet the State's most pressing educational problems. What might it do, for example, for the following?

Students Dropping Out of School

The number of Californians who drop out before graduating from high school remains unacceptably high. Resulting economic and human losses are well-documented, as are the possible causes and factors associated with dropping out, yet the role technology may play in combating this tendency has not yet been articulated.

Educators have found that their students become more motivated when given the opportunity to use educational technology; at-risk students can particularly benefit from such opportunity. Students who have been relatively unsuccessful with the paper and pencil environment of traditional school work often respond well to the more interactive realm of the computer. Instructional technology is capable of presenting material in a variety of ways (i.e., visual rather than equational representation of math concepts, alternatives to the traditional lecture format), thereby accommodating students' divergent learning styles and increasing the likelihood that all students will succeed. Additionally, the new technologies are very well-suited to the individual tutoring and remediation needed to increase the confidence and academic skills of at-risk students. Indeed, simply learning how to operate a computer or laserdisk player can be important, since mastery of anything associated with school may become an incentive that makes the difference in a student's decision to drop out or remain in school, and learning a skill that is relevant in the workplace may alter students' opinions about the applicability of school work to real life.

Population Growth and Overcrowding

California's population continues to grow, resulting in the overcrowding of educational institutions at all levels. At the same time, an increasing portion of the population desires access to higher education. The result is that we are entering a period of physical expansion: new schools and campuses will be planned, funded, and constructed at a rate perhaps equaling the State's boom period of growth in the 1950s and 1960s. The role technology may play in the planning, design, construction, and indeed the need for, these new educational institutions must

be fully considered. With rapidly evolving instructional, research, and administrative technologies, an increasing level of expertise with technology among educational professionals, and an expanding infrastructure of computing and communications technologies, completely new educational strategies and formats are possible.

Adult and Non-Credit Education in Basic Skills and English as a Second Language

The demand for adult education courses in English as a Second Language and basic skills at adult schools and community colleges is burgeoning and will continue to grow. Immigrants and high school dropouts returning to the classroom as adults are flooding the State's school systems in search of opportunities for learning. The use of technology to deliver instruction and to monitor and encourage individual progress needs to be considered seriously when developing ESL and basic skills adult and non-credit education programs. Since students participating in such courses are usually well motivated, a course design that requires a certain amount of individual work, monitored by a computer, may prove a format that allows for quicker progress and more cost-effective delivery of instruction. Further, experience with classroom computer technology will provide students with a familiarity with computer technology that can benefit them in the job market, or may inspire them to further study.

Low College-Going Rates for Certain Minority Groups

It is well-known that Black, Hispanic, and certain other minority groups are enrolling in California's institutions of higher education at a lower rate than are white students. Through the use of telecommunications technology, a potential solution to this problem is now being explored. Credit courses originating at a college or university can be transmitted to high school sites, offering interested minority students and others the opportunity to participate and earn college credit while still in the familiar surroundings of their high school. Successfully completing one or more freshman courses before formally entering college may increase the likelihood that minority students will enroll and succeed in college.

A Shortage of Qualified Teachers

The shortage of qualified teachers in the schools -- most notably in mathematics and the sciences and in specific geographical regions of

the State -- often results in faculty being assigned to teach subjects in which they are unqualified, or even not offering certain college preparatory or advanced-level courses. Over 50 percent of the new teachers hired in the Los Angeles Unified School District do not yet have teaching credentials, and are required to complete their credential coursework while teaching during their first year. Many drop out due to the combined strain of first-year teaching, commuting through rush hour traffic to universities, and taking credential courses at night. The delivery -- through telecommunications technology -- of courses taught by qualified university instructors to these teachers at their schools or district offices would lighten their burden, ensure that they receive quality instruction, and increase the likelihood that they will finish their credential and continue to teach. Similarly, telecommunications technology can be used to deliver courses leading to advanced education degrees to teachers at their worksites.

The shortage of qualified teachers in rural and inner-city areas may result in another problem: students from rural and inner-city schools are much less likely than others to graduate from high school eligible for college admission, partly because college preparatory courses are not available in their high schools. Again, interactive courses can be delivered through telecommunications technology to all the rural and inner-city secondary schools of the State, ensuring that a full curriculum, including college preparatory classes, is available to every California high school student.

Goals for Educational Technology

Projecting the future of technology in education is no longer a highly speculative exercise. Such a vision can now be built on solid foundation of fact and reality. Building it, in fact, has become a necessary step in educational planning and the formation of public policy. Without a clear conception of what California should be aiming for, the integration of technology into the educational process is likely to remain sporadic, uneven, and inefficient. We believe it is far too important for both education and California's economy to allow future development to occur randomly, be thwarted by partisan politics, or impeded by lack of cooperation among the systems of education, faculty and teachers organizations, the business community, and public officials.

Convinced of technology's vital importance to education, we propose that California achieve the following conditions as soon as possible and no later than the year 2000:

1. **An educational environment in which all students and faculty can realize the full benefits of technology.**

   The extraordinary potential of technology as an aid to learning makes it imperative that all students and faculty be able to exploit this potential to the limit of their interest. A situation in which some portion of students and faculty in the State are denied this opportunity will be unacceptable. Achieving this objective in a timely fashion will require a major commitment of public funds for the purchase of equipment and programming, and for the ongoing operational and personnel costs to maintain the information technology infrastructure. It will also require new levels of cooperation among all systems of education and among educators and the business community. It will require individual creativity, comprehensive planning within each segment, and coordinated intersegmental planning where shared resources are both program effective and cost efficient.

2. **A learning environment in which technology is directed toward ensuring the success of the individual student.**

   Through the use of technology, students have access to instructional modes most appropriate to their needs and skills, and are able to progress at their own pace. This practice can help avert school failure, and encourage and motivate students to progress quickly through material that engages their interest and involves their active participation. Technology also decreases the time teachers must spend on time-consuming reporting tasks, freeing them to devote more time to individual students. Administrators and teachers can use technology to monitor individual student progress ensuring that each student continues to learn and progress at an acceptable pace.

3. **Access -- through digital networks and other technologies -- for faculty and students at all levels to remote computing resources, to a community of scholars, and to collected bodies of comprehensive information that will enhance the teaching/learning experience and professional performance.**

Digital networks capable of transmitting data, sounds, and images will allow the instantaneous sharing of resources and information among all members of the educational community. A vast store of up-to-the-minute facts, statistics, collected and archived resources, figures, and photographic images -- the raw materials of scholarship -- can be available to facilitate study and collaboration among teachers and faculty in all disciplines at all grade levels.

4. **Extensive instructional opportunities -- through information technology delivery systems -- at proximate locations for all students and adults of the community.**

   These opportunities will benefit a classroom of students receiving a full course of instruction at a remote site, as well as an individual student accessing stored information in the form of pictures, sounds or text in order to explore a subject of personal interest.

   Opportunities for all citizens who desire instruction should be unconstrained by geographical location, overcrowding, or teacher shortage. Rural and inner-city secondary schools often do not have the teaching personnel to offer a full-range of college preparatory courses. Similarly, adults in rural areas or professionals in their workplaces often do not have the opportunities to pursue continuing education or training. The increased use of information technology for distance learning should assure that no students are denied the education they desire, whether it be for college preparation, U.S. citizenship requirements, enhanced employment opportunities, college credit or personal fulfillment.

5. **Routine opportunities for all faculty to become thoroughly familiar with information technology and to be rewarded for creative applications of technology to instruction and research.**

   The educational benefits of information technologies will be realized only if faculty are comfortable with, proficient in, and fully informed about, the possible applications of technology to their disciplines. This level of familiarity will require concerted efforts to create opportunities for faculty training and experimentation, with the expectation that the State, to some extent, will subsidize such activity. Concurrently, a range of incentives, including proper professional recognition, must be available to faculty members for creative applications of technology to the instructional process. Software author-

ship must come to be viewed as important a contribution to a discipline as other professional activities.

6. **A climate that encourages the innovative use of technology in instruction and that automatically considers how technology might contribute to the solution of educational problems.**

   Anticipating further evolution of the new technologies, we must create an environment in which instructional practices evolve in harmony with technological possibilities. We must encourage the application of technology to some of the State's current educational problems. In seeking answers to any of the challenges facing education, we will want to ask, early on, what technology can contribute to its solution.

7. **An active partnership between education and the business community working cooperatively to develop technology that will benefit learning and produce students who will be productive participants in the information-based economy of the twenty-first century.**

   The new technologies have resulted in an unusual sort of interdependencies between the business and educational communities. Businesses, as they use more sophisticated technologies and seek more capable workers, will increasingly insist that school graduates have the problem-solving and life-long learning skills that these more challenging positions require. Educators, too, depend upon businesses, particularly the technology industries for products that are ever more affordable, easy to use, and adaptable to educational purposes. While the technology industry has supported specific segmental projects, we believe all industry should participate more formally and systematically through a statewide forum that includes business, educational, and governmental officials in discussions about changing workforce needs and the best uses of technology in education. Partnerships between educational institutions and business and industry could be highly beneficial to both sides and to the State's economy.

In Pursuit of These Goals

In order to achieve these goals, all segments of education, state govern-

ment, and business and industry must coordinate their planning for the expanded use of information technology. The rapid emergence of technology as a force in education demands the careful consideration of its role in the overall structure of California's system of education. Communication among the segments is essential to identify areas of potential cooperation, to ensure that all of the State's students have access to the benefits of information technology, and to minimize unnecessary duplication of effort. This cooperative action should take place in a way which balances the need for statewide coordination with a concern for local initiative and independence of action.

There is no escaping the fact that significant additional educational expenditure will also be critical to the accomplishment of these goals. Redirection of existing allocations alone cannot suffice, and thorough cost/benefit analysis will be required in the development of funding schemes.

2 Technology in Use

ALTHOUGH most California students still find themselves in decidedly low-tech, traditional classroom surroundings in which print and formal lectures are the principal means of instruction, some California educators and institutions have enthusiastically embraced new educational philosophies which include the use of technology. Examples can be found at all educational levels and in all disciplines of uses of technology that are transforming modes of inquiry, heightening opportunities for students and faculty, and making possible educational outcomes never before imagined. A smattering of examples of uses of new and emerging technology by California students and educators follows:

- A high school student in rural Happy Camp, on Highway 96 west of Yreka, is taking a marine biology class that is being offered at his school by live interactive satellite instruction that originates in Texas. Other students are taking calculus, Japanese, and French IV -- all courses that could not be offered if it were not for the school's ability to conduct the instruction via telecommunications. High school students in 21 other relatively isolated communities throughout the State also receive this instruction via satellite. Programs such as these make complete high school curricula available to every student, regardless of their location, and help increase the likelihood that rural students will go on to study at colleges and universities.

- A student at Monterey Peninsula College visits the High Tech Center for the Disabled daily to write papers and work on assignments. Quadriplegic, as a result of a car accident, he uses a headstick to strike keys on the computer keyboard, and experiences a greater degree of independence in his school work than was ever before possible. Special word processing software that reduces the number of keystrokes it takes to spell common words is used in order to reduce the amount of time necessary to write. Many hardware and software tools have been developed which give people of varying disabilities the opportunity to use computers for their college work and to gain employment skills.

- A freshman physics major at California State University, San Bernardino, uses a computer and instructional software to reinforce concepts she is learning in her introductory physics courses. One program models energy transfer, allowing her to turn up the heat on a

container of gas and observe the thermodynamic phenomena such as heat, work, and pressure that the software models. Since scientific concepts are often difficult for undergraduates to grasp, and laboratory experiments are costly and time-consuming, using a computer to simulate phenomena allows students to repeat a process as often as necessary to gain understanding of the principles involved.

- An advanced placement history student at a Bay Area high school uses a computer in class to create a multi-media term paper on Prohibition and its repeal that includes filmed images, graphics, and text she has written. Using a laserdisk player and hypermedia software -- computer software that allows the user to create programs that incorporate varied media and organize the material using logical associations -- she organizes the term paper so that readers can start at one of several points and explore various topics having to do with Prohibition and its repeal according to their interests. Each student in the class completes a project on some aspect of American history, working individually or in small groups, according to their choice. The educational experience for the students is rich: motivation is high; they research their topics thoroughly; analyze and synthesize information; make decisions on lay-out, design, and logical presentation; explore the projects of other students with interest; and master state-of-the-art technologies.

- A student who lives and works full time in Manteca is working toward a two-year associate degree at San Joaquin Delta College in Stockton. Making the commute is difficult, especially with working full time, but fortunately three days a week she is able to attend a noon-hour course, in Manteca, not far from where she works. The "Introduction to Statistics and Probability Theory" course is transmitted to downtown Manteca and several other sites throughout the northern San Joaquin Valley from a television studio on the college campus. Students at all locations can interact with the instructor and other students at the home campus, and the units they earn will be recognized by the University of California and the California State University for transfer.

- A fifth-grade teacher in Bakersfield spends part of each summer training small groups of colleagues from his district in ways to integrate technology into their teaching. He shows them how to set up word processing templates they can use to more effectively plan lessons, report grades, create tests and worksheets, and write letters to parents. He introduces them to various educational software programs, and they discuss strategies for integrating them into their

curricula, as well as strategies for conducting classroom writing activities in which students use technology. At the end of the two-week training session, all the teachers are given communications software and taught how to access a local electronic bulletin board so they can continue to communicate with one another throughout the school year, exchanging ideas and strategies on how best to integrate technology into elementary school teaching.

- A UCLA freshman completes much of her coursework in Elementary Symbolic Logic using a computer tied to the campus Social Sciences Computing Network. A computer program allows her to do all of her logic homework at the computer and provides her with instant corrections and explanations. The immediate feedback and tutoring features and the increased peer interaction that takes place in the computer labs have a significant educational benefit for her and her fellow students. The productivity of the teaching assistants in the course also improves, since they spend more time individually with students and less time correcting papers.

- A third-grade student at the California School for the Deaf uses a computer program that accesses laserdisk video images in order to increase his reading and writing ability. The program capitalizes on his fluency in American Sign Language to improve his written English grammar and vocabulary. He can watch a story in American Sign Language or read it in English, switching back and forth between signed and written versions of the story as needed for comprehension. The program also contains tutorial and drill functions that guide him through comprehension and captioning exercises.

- An elderly retired couple in Los Angeles County enroll each semester in a telecourse from Coastline Community College. The lectures are broadcast on cable television, a textbook and assignments are mailed to their home, and they have periodic conversations with the course instructor over the telephone. The convenience of learning at home attracted them to the courses originally, and the satisfaction they receive from completing them prompts them to enroll in a new course each semester. They are accumulating units and may decide to work toward degrees, but they enroll primarily for satisfaction of continuing to educate themselves.

- A seventh-grade English and social studies teacher in San Diego County designs a two-week series of lessons in which her students choose a famous American site or landmark and create a video describing its history and significance. Students, working in small

groups, learn to use a laserdisk player, a VCR, editing equipment, and a word processor to complete their projects. They write the scripts, narrate, edit, and do all other tasks necessary to produce the videos, demonstrating technical, problem-solving, writing and group process abilities. At the conclusion of the two weeks, the instructor notes that the students learned surprisingly quickly how to use the equipment, and that they expressed more enthusiasm for the project than they had for anything else in school that year. This group of students are considered by their teachers, even in junior high, as not college-bound and not motivated toward school work, yet they demonstrate pride, ability, and enthusiasm throughout the period of production of their projects.

- A high school dropout has recently dropped back into school, hoping to prepare herself to pass the mathematics portion of the high school proficiency exam. The adult education center she attends has a drop-in computer lab with various math software, so, in addition to attending class, she works independently in the lab several times each week. A lab instructor is always available to show students how to use the equipment, recommend software that would best meet their needs, and to help them master the subject matter.

- A student majoring in Industrial Design at California State University, Long Beach, uses a computer work station and design and simulation software to complete most of his required course projects. For one class project, he creates a circuit board using design software, and then tests its connections using software that simulates the flow of the electrical current. If the circuit board doesn't test out correctly, he continues to redesign and retest it until everything is right and it is ready to be rendered in final blue print form. Design and simulation software is being used by engineers, architects, and designers in varied fields, and is increasingly being incorporated into baccalaureate programs.

3 Initiatives in Educational Technology

Initiatives Within California

Each public system of education in California has recognized the importance of planning for educational technology, and has made an effort to develop and encourage organizational structures consistent with the missions of its institutions. Devising instructional, administrative and research strategies that incorporate the new technologies, redefining priorities in light of technological change, and incorporating or assessing the potential of new developments requires planning at all levels. Broad-based planning efforts for educational technology are described below:

California State Department of Education

Legislation in 1983 provided State funds for educational technology programs. It also established an Educational Technology Committee charged with oversight and planning for future projects, and an Educational Technology Office within the State Department of Education charged with administering the programs. State-level activities since 1984 have included, among other things: summer technology institutes for teachers, model technology schools, software development partnerships, support of instructional television programming, and providing over $53 million in small grants to encourage schools to begin or expand their efforts to improve instruction through the use of educational technology. These small grants have been credited with promoting much of the current use of educational technology in California schools. School- and district-level planning for educational technology has also been encouraged through State-level activity, since the awarding of grant monies has been tied to site planning.

California Community Colleges

Although there exists no comprehensive plan for technology use within the community college system, there has been systemwide planning for specific projects. Development of a Management Information System data network connecting the 107 colleges with the State Chancellor's Office in Sacramento is in the early stages of implementation. The planning and establishment of campus High Tech Centers for the

Disabled began in 1986 with a $1.2 million grant from the Community College Foundation. At the completion of a phased implementation period, each college will have such a center, equipped with adaptive hardware and software which enable students with varying disabilities to have full access to the benefits of the computer. Two Community College Television Consortia, administered cooperatively by the colleges without involvement of system administration, have operated for more than 20 years. The consortia, comprised of approximately 79 member colleges, produce programming, provide support services for broadcast telecommunications, arrange cooperative purchases and other resource-sharing activities, and provide videoconferencing services.

The California State University

The California State University s overall information resources management program includes a well-defined process for planning for information technology throughout the system. Individual campuses develop annually a five-year campus information resources plan which is reviewed by the Chancellor's Office and incorporated into an overall systemwide plan. Integral to this planning process is interaction with State University systemwide advisory groups representing academic computing, telecommunications, library, information resources management, instructional technology, and executive management. For example, one systemwide advisory group -- the Commission on Instructional Technology -- offers policy advice to the Chancellor concerning the use in instruction of new and emerging technologies. Additionally, there are several system-wide discipline groups whose purpose is to advance the use of technology for instruction and research within their fields. Awards are also made each year to faculty for academic computing enhancement and professional development projects involving technology.

In 1986, in collaboration with the University of California, the State University developed a planning model for the forecasting of the equipment and software needs for instructional uses of computing. This model, endorsed by the California Postsecondary Education Commission, has served as the basis for the State University's requesting State funding for academic computing. Unfortunately, the State has only provided minimal funding utilizing this model.

The State University has established a data network (CSUNET) which links all campuses for educational, research and administrative purposes, with a gateway to Internet and its related services. The CSU-

NET, in addition to providing access to specialized academic resources within the State University, links to the San Diego Supercomputer Center, has a Bitnet gateway, and provides, through public access "ports," bulletin board services to high school counselors, agricultural information to California farmers, as well as other similar outreach services. Further enhancements are now being implemented, including adding several community colleges to the CSUNET as a pilot project, providing electronic information services to K-12 educators as part of the California Technology Project, and linking to the University of California's network to provide CSU faculty members access to MELVYL, the University's on-line database of library resources.

The California State University makes extensive use of video telecommunications technology. Several instructional television networks exist, the largest of which is the Central Valley Network connecting all campuses and various off-campus sites between Chico and Fresno. Fourteen campuses regularly transmit courses to off-campus locations. California State University, Chico, has particularly extensive course offerings, including undergraduate and master's degree programs in computer science that are transmitted to 11 states. Each campus in the system also has satellite reception capabilities and 10 campuses can transmit video via satellite. All campuses have access to the portable uplink located at California State University, Sacramento.

University of California

Planning, evaluation and policy oversight for information technology activities in the University of California is provided by three university-wide groups composed of faculty, staff and administrators from the various campuses and the Office of the President. The Academic Computing Council advises the Office of the President on all aspects of instructional and research computing and related telecommunications issues. The University Communications Planning Group addresses voice and data communications, including both academic and administrative computing needs. The UC Library Council advises the President on matters related to the UC library system, including the development and use of information technology in libraries.

The University's Intercampus Telecommunications Network (ITN) is a high-speed data network which connects the nine campuses and the Office of the President and supports three distinct network services. One service, based on IBM telecommunications protocols, is used predominantly for administrative applications and electronic mail. A second network service supports University-wide access to MELVYL on-

line catalog and provides connections among local area networks at all campuses. Through gateways at the campuses, this network also provides access to various regional and national networks. A third network service provides access to the San Diego Supercomputer Center.

The San Diego Supercomputer Center (SDSC) is one of five national centers sponsored and partially funded by the National Science Foundation. SDSC is located at the UC San Diego campus, is operated by General Atomics under contract to the National Science Foundation, and provides state-of-the-art supercomputing as well as educational and consulting services to members of the SDSC consortium, California State Government, and other public and private organizations in California and throughout the nation.

In the area of library service, since 1977 the State has provided budgetary support for the development and operation of the MELVYL online union catalog, which provides users with convenient bibliographic access to the library materials of all UC campuses. The MELVYL catalog currently contains records for almost 10 million books and over 1 million periodical subscriptions and is used by more than 260,000 library users each month. The MELVYL catalog also includes the MELVYL MEDLINE database of journal article abstracts produced by the National Library of Medicine, and planning is underway to incorporate additional journal article databases in the catalog.

University-wide planning for the instructional use of technology began in 1983, when the University convened a task force including faculty from a range of academic disciplines to develop a plan for estimating student need for access to computing by discipline. The State has accepted the Instructional Use of Computing (IUC) model developed by that task force in collaboration with the State University, and has provided budgetary support for its implementation. The University-wide IUC Evaluation Group (now a subcommittee of the Academic Computing Council) continues to evaluate the implementation and educational effectiveness of the IUC program through a survey of stratified random sample of UC students.

All nine University campuses also use video technologies to support instruction and faculty research activities, including multimedia video, interactive distance instruction, video dissemination, video archives and videoconferencing.

Intersegmental or Cooperative Efforts

Intersegmental coordination and sharing in educational technology planning and resource development has begun to occur in recent years. Seven such efforts involving more than one of the public educational systems, however, have been initiated within the past several years.

- *Instructional Uses of Computing*, a joint effort by the California State University and the University of California to develop a planning and funding model for the acquisition and support of computing equipment and software to be used by students in the instructional process, was endorsed by the California Postsecondary Education Commission and is used by the State in budgeting funds for the instructional uses of computing by both systems.

- *Governance Options for the Development of a California Backbone Networking Activity*, a study recently commissioned by the University of California, the California State University and BARRNET, explores options for establishing a statewide education and research network.

- *The California Technology Project*, a combined effort of the State Department of Education, the California State University, and K-12 educators will, among other things, establish and coordinate a computer-based educational telecommunications service disseminating information about educational technology programs within the State; establish and coordinate the activities of regional consortia that will provide for K-12 staff development in technology; coordinate efforts related to the evaluation and dissemination of information about instructional technologies research and evaluation, as well as technology-based curriculum materials; and assist in the development of plans for the future uses of technology in the schools.

- *The Northern California Community Colleges Television Consortia*, one of the two community college television consortia in California, has recently opened associate membership to northern California campuses of the University of California and the State University.

- *California Internet Federation*, a combined effort of major private institutions in the State and the two public university systems, is examining options to provide a comprehensive networking capability for all segments of education in California.

- *San Diego Supercomputer Center (SDSC)*, established in 1986, is one of five national centers sponsored and partially funded by the Na-

tional Science Foundation. The SDSC was developed by a consortium which includes University of California and California State University campuses, as well as several private universities and research institutes. Funding is provided chiefly by the National Science Foundation, the consortium members, and revenue from the sale of computer time to non-consortium members. Recently, the State of California allocated resources to support the development of advanced graphics facilities at SDSC.

- *California Education and Research Foundation Network (CERFNET) and Bay Area Regional Research Network (BARRNET)*, located respectively in southern California and northern California, are regionally-sponsored data communication networks. Comprised of members from the two university systems, the community colleges, and private corporations, CERFNET connects 38 research centers and BARRNET connects 12 research centers. Grants from the National Science Foundation helped to establish the networks.

- *CSU-Community College Networking*, a project designed to link the community colleges to CSUNET, is currently being implemented as a pilot project on four community college campuses. The project was launched to connect the Office of the Chancellor of the California Community Colleges and the community college campuses into CSUNET to facilitate the movement of administrative and instructional data.

- *Western Interstate Commission for Higher Education (WICHE) Western Cooperative for Educational Telecommunications*, still in the developmental stages, includes 100 member institutions from fifteen western states that plan to share resources and cooperatively plan and deliver programs in the area of educational telecommunications. Several California campuses and institutions are members of the Cooperative.

Professional Organizations

Statewide professional organizations which focus on the use of technology in instruction, such as Computer Using Educators (CUE) and the California Media and Library Educators Association (CMLEA), are often the source by which most K-12 educators keep informed of developments in educational technology. CUE, for example, through its substantive newsletter, semi-annual conferences, and network of local af-

filiate groups provides support, education and advocacy for its estimated 8,000 teacher and administrator members.

Joint Education and Private-Sector Endeavors

- *Pacific Bell/CSU Bakersfield Distance Learning Project.* California State University, Bakersfield, is expanding its existing educational telecommunications offerings through a partnership with Pacific Bell. The rural town of Tehachapi will receive college credit instruction originating from the Bakersfield campus. The courses will be transmitted over copper telephone lines through a process of compressing the video image, thus two-way video and audio interaction between the teacher and the students at various locations will occur over the same line. This will be the first project ever to offer two-way interactive video distance instruction to a school site over regular phone lines, rather than through broadcast, ITFS, or cable media.

- *Software Development Partnerships.* The State Department of Education and the Educational Technology Committee have joined together with several software development firms to produce software for use in California classrooms. The State provided a portion of the development costs of the programs and in return will receive royalty payments and receive discounts for California schools wanting to buy the programs.

Activities Outside of California

Other Countries

Governments throughout the country and around the world have recognized the need to act decisively in response to the promises of technology applied to education. For example:

- France set three clear objectives as early as 1983 for the introduction of new information technologies into education -- they should be part of general education for all; they should make teaching more effective; and they should renew and update vocational and professional education. In 1985, an ambitious plan called "Informatics for All" and costing 2 billion French francs intensified teacher training and stipulated a further objective: school computer equipment should be made available to the rest of the population during after-school

hours (Organization for Economic Cooperation and Development, 1986, p. 21).

- Great Britain, with a much less centralized educational system, has implemented an equally "comprehensive" policy approach. The "Microelectronics Education Programme," launched in 1980, had as its purposes to provide information and advice to all schools through a number of regional centers; assist with intensive courses of teacher training; develop curricular material and software, and encourage the pooling and distribution of software. In 1984, the "Computers in Teaching Initiative," cosponsored by two governmental agencies -- the University Grants Committee and the Computer Board for Universities and Research Councils -- established pilot projects on instructional computing in every British university. Some 140 projects had been funded by mid-1987, including at least one in all academic disciplines. Its Support Service, based at Bath University, disseminates information about the projects to the academic community throughout the United Kingdom (Sprecher, 1988, p. 28).

- Italy has launched a national plan for the large-scale introduction of technology into schools. According to the Minister of Education, the aim is not simply to make computer studies part of the general curriculum but to use the new technologies to change the content of subjects already in the curriculum (Organization for Economic Cooperation and Development, 1986, p. 22).

- Japan allocated two billion yen through the Ministry of Education in 1985 to assist in the introduction of computers into schools at all levels.

- Ontario, among Canadian provinces, offers an example of a comprehensive policy approach to the integration of technology into education, with hardware, software, teacher training and curriculum development all part of the same policy agenda.

- The Soviet Union's Central Committee of the Communist Party, in its 1987 report, *Fundamental Guidelines for the Restructuring of Higher and Secondary Specialized Education in the Country*, noted that "the supply of computers and other contemporary technology to educational institutions is wholly unsatisfactory," and "it is essential to provide the educational process with as much computer technology as it needs during the Twelfth Five-Year Plan" of 1986 to 1990. The *Guidelines* call for 130,000 new work stations equipped with personal computers and terminals, along with the organization

of higher education multiple-access networks and information banks, the improvement of information services for the teaching process and scientific research, and the forming of "programming" centers for the development of software (*Soviet Education*, 1987, p .157).

Other States

In this country, significant state-level activity in planning and organizing for the increased use of technology in education has been taking place, serving to point up the relative absence of such activity in California. The efforts are usually initiated by the governor, the legislature, the state-level higher education coordinating or governing body, or the state department of education. While state-level activities vary widely according to the type of educational technology being considered, they can be grouped into several categories, each of which suggest possible steps this state may consider:

- *Establishment of distance learning delivery systems.* The advent of technology that allows for telecommunicated instruction with two-way interactive features has prompted a surge of interest in alternate methods of instructional delivery. State efforts range from pilot projects in New York to provide high school courses to rural areas, to extensive state-wide systems, such as Oregon's Ed-Net, which will provide instruction via telecommunications to learners throughout the state in libraries, hospitals, factories, state agencies, and businesses, as well as to educational institutions. Among other states that have made substantial allocations to plan or build educational telecommunications systems are: Arizona, Connecticut, Idaho, Indiana, New Mexico and North Carolina.

- *Development of long-range plans and the establishment of policies for the use of educational technology.* Legislatively formed committees with representatives from higher education and the public schools were convened in both Connecticut and Minnesota to develop comprehensive policies and planning for the use of technology at all educational levels. Other states, including North Carolina, New York and Massachusetts, have developed statewide plans for the use of technology in the public schools, and several have developed statewide plans for the comprehensive use of technology in higher education or within a higher education system.

- *Connection of all educational institutions within a state by electronic data networks.* The Florida Information Resources Network is per-

haps the most comprehensive statewide effort in electronic information exchange, connecting all 67 of the state's public school district offices, 25 of the 28 community colleges and each of the state's nine public universities. Other states are planning or funding similar projects in either higher education or the public schools, such as Massachusetts' Higher Education Computer Network, and the Kentucky Educational Network System. California's public four-year institutions have attained a considerable degree of connectivity through their respective networks, and planning is underway for a more comprehensive statewide educational data network.

- *Creation of statewide governance or organizational structures for educational technology.* Governance and organizational structures to coordinate or plan for state's educational technology activities come in the form of advisory councils, task forces, voluntary cooperatives, or quasi-governmental agencies involving the private sector. The Governor's Advisory Council on Advanced Technology in Schools advises on the use of educational technology in Washington's public schools, as do many varying structures in other states. Arizona is one of several states to initiate an educational telecommunications cooperative. The Instructional Microcomputer Project for Arkansas Classrooms and the Massachusetts Corporation for Educational Telecommunications are examples of educational technology organizational structures involving the private sector. Several interstate cooperative efforts also exist, including the Western Interstate Commission for Higher Education's Western Cooperative for Educational Telecommunications. The Cooperative, still in the developmental stages, includes 100 member institutions from 15 western states that hope to share resources and cooperatively plan and deliver programs in the area of educational telecommunications.

- *Creation of comprehensive state-wide communications systems connecting government, business, and education.* A few states are establishing elaborate communications infrastructures that will allow for the communication of varying combinations of voice, data, and video signals by a single telecommunications medium. These systems are often projected to stimulate economic growth by increasing interaction between the private and educational sectors within a region. Oregon's Ed-Net is projected to facilitate data and video communications and serve the business, education, and government communities. Indiana's Higher Education Telecommunication System now provides voice, video and data communications for state agencies and education. Illinois has completed plans and has recently

awarded a contract to begin a seven-year process of building a similar comprehensive network.

- *Legislation to plan and fund educational technology projects.* Much of the major state-level involvement in educational technology is authorized through legislation. An act passed recently in the state of Washington requires the Superintendent of Public Instruction and the Higher Education Coordinating Board to develop a coordinated plan for a statewide telecommunications network. Other states that have enacted legislation in the past several years to plan or fund major projects in educational technology include: Arizona, Arkansas, Florida, Illinois, Indiana, Kentucky, Michigan, New Mexico, North Carolina, Oregon, Texas, and Virginia.

4 Barriers

DESPITE all the indications of promising activity, serious barriers to the full use of information technology in California's educational institutions still exist. Too many students continue to progress through our educational system uninspired and under-achieving; too many faculty continue to have no access to technological tools that would enhance their performance; and most teaching still relies on pedagogical modes untouched by the information technology revolution. Technology is not a panacea for all of education's problems, but is in the process of carrying us -- for better or worse -- into a new era of educational practice. Since some applications of the new technologies to education we will see in the next decade or two have not yet been invented, and many are in an embryonic stage, the cultivation of educational institutions and educators who are adaptable, experimental, and capable of progress is critical. Now is the time to identify those barriers impeding the adoption of new ways of teaching and learning and to take steps to overcome them, so that all students, faculty and administrators may be full participants in the information society of tomorrow.

1. Attitudes Toward Technology

Accepting Change

The Legislature and the educational community must recognize that if California is to use technology to its greatest potential for education, major administrative and instructional changes must occur. These changes will certainly not happen immediately -- but Californians should be open and flexible to changes based on the opportunities and requirements of the evolving technologies. Evolution of the information technologies will allow great independence of students and easy access to individually-tailored instruction. But in order to take advantage of these advances, educators, legislators and citizens will have to make major decisions about the traditional structure of our education systems. Class-size, the structure of the school day, instructional strategies, and how we budget and plan for education will all have to be reconsidered.

View of Technology-Based Instruction as Inferior

Many people are still skeptical about instruction that makes extensive use of technology. The stigma attached to technology may be fostered by its occasional misuse and perhaps also by the belief that technology is impersonal and incapable of engendering the element of human sharing essential to the art or teaching. While these concerns cannot be dismissed lightly, they must be weighed against enormous advantages that technology promises, and against the repeated findings that the proper use of computer and communications technology can be as effective, if not more so, than traditional methods, and that peer interaction and cooperative learning is enhanced.

View of Technology as a Frill

Some educators continue to view technological tools as moderately useful but certainly not essential; a lingering few still call them gimmicks. Indeed, as these tools are currently used in some school settings they would have to be labeled non-essential. Yet, when we consider technology's future role in education and in society, we realize that what is at stake are tools so useful that each student, teacher and research faculty member who does not have access will be seriously disadvantaged. Students who do not achieve mastery of the technological tools, who do not learn to explore and access information useful to their lives, or who do not have some understanding of how information technology can change business and personal relationships, will not be prepared to function in tomorrow's world. Viewing technology as ancillary to genuine instruction is clearly an impediment to its most creative use and development. It a view that must be altered.

---

2. Bureaucratic Constraints

Freedom and Encouragement to Innovate

A flexible environment that respects and encourages individual creativity and initiative is optimum for adapting to the technological changes in education. The administrative hurdles individual educators face when attempting to take advantage of the changing technologies are often disheartening, difficult to overcome, and detrimental to progress. A cumbersome budget process, unsupportive administrators, unresolved legal issues, outdated regulations and funding formula and

other trappings of resistance to change may severely hamper experimentation, causing creative and motivated teachers and faculty to give up the struggle. Some of California's best and most highly motivated educators are those who have quickly seen the potential of technology to enhance their own performance, and who have made the extra effort to ensure that their students benefit, too. These innovative educators and creative thinkers are critical to the future of education and must be encouraged and supported, not hindered. At the same time, incentives should be identified to encourage faculty resistant to using technology to explore the benefits of incorporating it in their teaching.

Just as individual teachers and faculty will be most productive, innovative and willing to change if they operate in an environment which respects, funds, and encourages their contributions to the evolving uses of technology, so too will our institutions, departments, and schools. Institutions, as well as individual departments and schools must be encouraged to develop and carry out their own site-based plans for improving education through the use of technology. As in other areas of public policy, the challenge is to create an environment which is as free as possible from administrative barriers imposed from above.

---

3. Limited Access to Technology

Need for More Equipment

Even though the amount of technology in schools and colleges has increased exponentially during the past five years, access remains limited, especially in K-12 settings. Given a rapidly evolving technology which renders some equipment obsolete soon after it is acquired, equipping and re-equipping classrooms with the electronic tools necessary for full student utilization will remain a central challenge indefinitely. This is especially problematic since the fiscal structure does not provide schools with the same financial incentives businesses have for depreciating equipment. This makes it more difficult for schools to purchase new equipment and instead encourages inordinate spending for the repair of obsolete and outdated pieces of technology. The challenge of ensuring proper equipment for all educational institutions, and the additional challenge of connecting educational technology resources for maximum efficient use, will require a coordinated approach among edu-

cation, government, and industry officials committed to achieving the best and broadest possible access to the benefits of technology.

Need for Programs that Make Use of the New Technologies

Most students and teachers do not now have sufficient access to the technological tools that they need. Indeed, many applications that would most benefit education still await development. For example, all teachers and faculty should be able to access electronically curricular and research resources that will aid them in their work. Data bases of information and sophisticated software that can assist the user in quickly moving through masses of data to find the needed material still await development. All students should also have access to intelligent tutoring software that can assess ability level, diagnose errors, and encourage students to remedy basic skill shortcomings, and to state-of-the-art subject matter software that, among other things, can impart information to students and thereby free teachers for coaching, diagnosing difficulties, and developing students' creative and problem-solving capacities. And all high school students, including those from rural and inner-city schools should have access to interactive courses covering the complete secondary curriculum. Technology can help small schools provide for the individual needs of each student and, at the same time, help restructure large schools into smaller, more effective units.

A number of factors hinder further development of technology-based educational materials and resources. Development costs are high; incentives for developing programs are often low; technology resources, such as data bases, are expensive to develop and maintain within any one educational segment; and problems involving the ownership of intellectual property, copyright issues, and standardization of hardware remain unsolved. As a state, we need to invest in the development of educational applications that will best exploit the new technologies. California should explore incentives for intersegmental program development, ways to encourage the private sector to develop exemplary software products, and opportunities for the business and educational communities to join forces to create the best educational technology resources.

4. Limited Staff Proficiency in Technology

Lack of Opportunities and Incentives for Teaching Faculty

Although resistance to technology on the part of instructors is probably diminishing by the day, some faculty may still be less than eager to incorporate it into their pedagogy. They may not have seen convincing enough demonstrations of technology's use for their classes, or, having evolved a teaching style they find comfortable, they may balk at making radical changes. They may not wish to invest the additional time and effort necessary for mastering the new information technologies or they may not have reasonable opportunities or incentives to do so. Or most likely, teachers and faculty may not have adequate access to the programming and equipment they would find useful for their teaching. Opportunities for faculty to familiarize themselves with the potential classroom applications of technology, and incentives and recognition for those who develop promising applications must become more abundant.

Insufficient Support Personnel

The number of professionals and technicians employed to support technology use in educational institutions is growing quickly and must continue to grow. School districts hire computer resource specialists and technicians, colleges and universities hire all manner of programmers, information systems planners and managers, and instructional technology support staff. These people are now necessary to the successful functioning of our institutions in the information age. Teaching staff need someone to consult with for at least technical advice, if not for advice on strategies for integrating technology in their instruction. Connecting information resources for more efficient use, a complicated endeavor that all organizations, whether public or private are currently involved in, may also require a serious increase in number of staff. An adequate technological infrastructure, which includes sufficient support personnel, must become a standard feature of California education.

---

5. Limited Cooperation Among All Systems of Education in Planning, Coordinating, and Evaluating the Use of Technology

As indicated earlier in this report, much has been accomplished in applying technology to instructional uses. This has happened largely by the initiatives of the respective institutions, with no statewide vision or educational philosophy to promote interinstitutional activities or to in-

spire public support. From a state-level perspective, there is much to gain from cooperative planning among the systems. Many objectives, such as achieving connectivity of resources, developing and promoting exemplary applications of technology in all subject areas, and training future teachers in the use of technology are simply unattainable without serious cooperation by all parties.

5 Recommendations

CALIFORNIA is famous world-wide as a leader in technological innovation: Nearly a third of the country's microchip producers and suppliers are California companies, our firms employ more electronics workers than the next three states combined, and our economy thrives as the sixth largest economy in the world.

The irony is that in a state as technologically advanced as California, so many of our schools, community colleges and universities continue to operate without taking full advantage of the multitude of advances technology now makes possible. In 1988, California was ranked forty-fourth among the states in the ratio of students to computers within the elementary and secondary school system; graduates continue to emerge from our teacher training programs unsure of how to apply computer and communications technology to their teaching; and our education systems still await the development of technology resources such as knowledge bases and networks that will usher faculty and students into the information age. In the belief that all the State's students and faculty deserve the benefits technology allows, and in keeping with our State's reputation for technological excellence, we propose the following recommendations:

1. Each public segment of higher education, the State Department of Education, and schools and school districts should prepare and maintain a strategic plan for information technologies consistent with, and in support of, their missions. The plans -- which should be incorporated into other school, campus or institution planning procedures -- should include, among other components, a description of existing information technology resources and uses, a projection of future needs, strategies for meeting those needs, and an analysis balancing costs against larger institutional and societal goals.

2. The Statutory Advisory Committee of the California Postsecondary Education Commission should establish a mechanism for intersegmental coordination and planning for information technology. The mechanism should include a process for determining shared goals, identifying priorities for cooperative activity, estimating costs, seeking joint funding for cooperative projects, determining responsibility and governance of shared projects, if necessary, and generally pro-

moting the development and application of information technologies to education.

3. The University of California, the California State University, the California Community Colleges, and the State Department of Education should cooperatively explore the technical, fiscal, and operational aspects of connecting and expanding existing networks into a statewide informational network which would link all campuses and school sites. This network should build on existing network structures, supplementing where necessary, to provide access to information for all members of the State's educational community.

4. Since faculty and staff development is imperative to the effective integration of technology into education, schools and campuses should be provided with additional resources for training of teachers in the use of information technologies and the application of technology to various disciplines. Schools and campuses should also employ technology as a delivery system for faculty and staff development in a variety of subject areas. Additionally, existing statutes dealing with staff development programs and pre-service teacher training should be fully funded and implemented.

5. The Department of Finance should work in conjunction with the California Community Colleges and the State Department of Education to develop funding formulas for State support of instructional technology, similar in concept to those developed jointly by the University of California and the California State University and endorsed by the California Postsecondary Education Commission for the support of instructional computing. A variety of fiscal solutions should be explored to encourage the purchase of new and the replacement of obsolete equipment. The development of consistent funding sources is necessary for schools and campuses to provide their students -- as they must -- with sufficient access to technology including open computer labs, no-cost print facilities, equipment loan programs, and other appropriate equipment.

6. In harmony with the Governor's recommendation that all the State's "knowledge workers" be equipped with appropriate technological tools (Office of Information Technology, 1988) teachers and faculty in public schools, colleges and universities -- as well as State workers -- should have ready access to appropriate technology. This condition should be stated as a goal and conscientiously pursued by all systems of public education.

7. The Governor and/or the Legislature should establish a forum through which State government, the educational community, and members of business and industry, particularly those representing technology and publishing industries, can jointly encourage and expedite the optimal use of information technology at all levels of education. Among other public services, the forum should:

   a. Officially recognize and support the most creative and effective technology-using educators and their projects, possibly through a system of annual awards and other incentives.

   b. Develop private/public partnerships and alternative funding strategies to support increased use of technology in instruction.

   c. Consider the State's role in promoting industry standards and shaping copyright policy and law, and in encouraging publishers of print materials to find mutually beneficial ways to make their products available electronically.

   d. Explore the role of technology in resolving the State's critical educational problems, and encourage the dissemination of effective solutions across schools and across educational institutions.

8. The Legislature should establish and fund a center or centers for the development, evaluation, research and dissemination of information on instructional technology. The center or centers should be intersegmental in operation, possibly under the auspices of the California State University.

9. The Legislature, the Department of Finance, and the educational institutions and agencies should consider the potential impact of information technology when planning and funding new capital projects and capital improvement projects on schools and campuses. They should consider the expanded use of information technology wherever possible to maximize the utility of new construction. With each capital proposal, the institution should be required to describe how it considered the potential role of information technology in determining the function and design of the structures, and how it explored the possibility of reducing costs associated with new construction through expanded use of technology. The California Postsecondary Education Commission, in its Long-Range Development Plan and Space and Utilization Plan, should also consider the impact technology will have on the design, construction, and need for expansion of the State's educational facilities and encourage the use of

planning and budgeting standards. Further, the Office of the State Architect should develop standards for revised classroom and school construction taking into account schools' information technology needs, and the State Allocation Board should adopt the standards as part of the requirements for the new construction of public schools.

10. Statutes establishing categorical programs for ESL, Special Education, At-Risk Students, and other target groups, should provide for the application of technology in conducting the programs, and encourage the flow of technology into poorly equipped urban and rural schools. Additionally, any existing statute that creates a disincentive for using technology to improve instruction should be revised.

11. The Legislature and the institutions of education should ensure that no student in the State, because of location or lack of teachers, is denied access to high quality instruction in a full range of subject areas. To ensure equity of access, greater use should be made of the delivery of instruction to off-site locations that technology allows. The expanded use of distance learning technology could ensure for example that:

    a. All K-8 students have access to foreign language instruction.

    b. All middle school students have access to solid, innovative science curricula.

    c. All high school students have access to a full range of college preparatory courses, regardless of the size and location of the school.

    d. All community college and university students have access to appropriate courses for credit delivered via telecommunications.

    e. All adults, regardless of location, have access to instruction in ESL, Basic Skills, and other adult and non-credit education subjects.

    f. All adults, regardless of location, have access to continuing education programs that reflect changes in career and business requirements of an information intensive economy.

g. All students have electronic access to library resources, whenever on-site library facilities are not adequate or available.

12. The Commission on Teacher Credentialing should continue to review and report on the adequacy of requirements for technology training for pre-service teachers and the effectiveness of the training being provided. In cooperation with the Commission on Teacher Credentialing, the California Technology Project should include among its current projects an assessment of the level of preparedness of beginning teachers in the uses of instructional technology.

13. To encourage increased availability to education of necessary information technology resources, while at the same time protecting the rights of the property owner, the Governing Boards of the public institutions of education should promote ethical standards regarding the copyright, publication, and distribution of instructional software and information available electronically. Toward this end, the Governing Boards should look to such efforts as the EDUCOM Software Initiative's publication, *Using Software: A Guide to the Ethical and Legal Use of Software for Members of the Academic Community,* and the State Department of Education's *Suggested County/District Copyright Policy and Regulations.*

14. To assist the Legislature in making decisions about the expansion of successful programs or the continued funding of projects, independent evaluations of special State-funded information technology projects such as the Model Technology Schools, the CSU-Bakersfield distance learning project, and other State-funded technology projects should be conducted periodically. Reports of such evaluations should be distributed widely throughout the educational community and the knowledge gained from these efforts applied to other schools through financial incentives.

Appendix: The Technologies Described

AS A MEANS of further defining the topic of this report, this appendix presents a brief description of technologies currently being applied to educational uses:

Computer Technology

The computer is at the heart of the current revolution in technological applications to education, and a myriad of computer types and sizes are in use in educational institutions throughout the nation. Elementary and secondary schools use almost solely microcomputers, with an occasional laboratory that has a larger computer with networked workstations. In postsecondary education, especially at the university level, where computer technology was put to use much earlier, mainframe computers with connected terminals were the first computers available. With the arrival of smaller computers on the market in the early 1980s, the types of hardware on campus diversified, and more and more faculty, students, and staff had easy and proximate access to computer technology. With the creation of the supercomputer and its accessibility through telecommunications, the computing power and storage capacity available to researchers and educators has been increasing tremendously.

Educational Software

Administrative Software: Computer technology is being used at all levels of school and university administration. Administrators use traditional word processing, database and spreadsheet software, operated on mainframe, mini, or personal computers, to accomplish a myriad of tasks. Specialty administrative software targeted specifically at educational institutions is also being used for such purposes as enrollment, student tracking, billing, scheduling, and recording grades. Virtually every aspect of school administration has been affected by the application of computer technology, and universities continue to make plans to enhance and expand their administrative computing capabilities.

Simulation and Design Software: Computer software that allows for real-world phenomena to be simulated offers exceptional current bene-

fit and future promise for research and instruction. Simulation allows researchers, instructors, and students to model phenomena that would be too costly, dangerous, time-consuming, or completely impossible to observe in the real world. Simulations are becoming more accurate and complex due to vast increases in computer storage and processing capacity, and to improvement in the ability of computers to display results graphically. These advances have resulted in simulation becoming a major research method in many fields, and its influence is bound to grow.

Tutorial and Drill and Practice Software: Tutorial and drill and practice computer software is gaining in sophistication and will continue to reinforce instruction. The computer has been described as the ideal teaching machine, able to prime and prompt behavior, reinforce it immediately, and move the student on to the next appropriate step. These are the essentials of good teaching. They are what a tutor with one or two students could do and what teachers with large classes simply cannot do. Software can present concepts, demonstrate skills, question and encourage students, and diagnose and correct students' errors. The benefits of this mode of instruction include individual pacing, motivating influences, student control, and pictorial displays. Although, drill and review software is most often used for basic skills or remedial instruction, examples of this type of software are occasionally found at higher levels.

Courseware Authoring Tools: Instructors can create their own software tailored to meet the instructional objectives of their courses through the use of authoring software. A job that used to take a tremendous amount of time and programming ability is now simplified to a point where virtually any teacher or faculty member can become a software author. A new generation of hypermedia software authoring programs further simplify the authoring process and allows for the creation of multimedia software that combines computers, still or video images, and sound in educational programs.

Computer Managed Instruction: Instructional management software allows teachers to use their computers to keep track of students' progress, compile test questions, inform students of their attainments, and other management tasks. For example, one instructional-management program allows teachers to use a central database of test questions to tailor-make examinations that reflect a school's curriculum and to compile individual profiles of student achievement.

Computer-Related Technologies

Optical Publishing: The computer compact disks (popularly known as CD-ROM) came on the scene recently and promise a great leap forward in external storage capacity for microcomputers. A direct descendant of the audio compact disk, the five-inch CD-ROM is currently capable of storing about 550 megabytes of memory; or approximately 5,500 pages of written information. Journal and library resource publishers, among others, have begun to take advantage of this technology. Abstracts of journal articles have been optically published on compact disks, enabling researchers to quickly find articles related to their topic.

Laser Disk Technology: Still or moving images, such as drawings, slides, or video sequences, can be stored on optical disks and accessed for use in instruction via laser disk technology. This technology was first used for instruction by the military and is now used in numerous academic disciplines and secondary and primary school classrooms. For example, laser disks containing photographs of the entire collection of the National Gallery of Art, or filmed images of twentieth century historic events, or filmed undergraduate physics experiments are being used to provide instruction and research opportunities which are far more cost-effective than traditional approaches. Used in conjunction with a computer, laser disk technology can be employed to create interactive video programs for instruction.

Multi-Media: Educational software programs exist which incorporate multiple media, such as video, animation, audio, and graphics, all controlled by a computer, and which allow for student interaction. The use of computer-based multi-media instructional programs is a recent development which will most likely continue to grow. Currently multimedia programs are being used to teach pre-service teacher education, literature, physics, engineering, among other subjects.

Telecommunications Technology

For the purposes of our discussion, educational telecommunications will be grouped into two main categories: (1) Data Telecommunications, referring to the transmission of computerized information over a distance for the purposes of administration, research, and instruction; and (2) Audio/Video Telecommunications, referring primarily to the transmis-

sion of sound and moving images over a distance for purposes of instruction.

Data Telecommunications

Local Area Networks: Increasingly, computer and telecommunications technologies are being used to link various computing resources throughout a given area, such as an office, a department, or a building. Users of the local area network can access all resources connected to the network, as well as communicate with other network users. Networking has become a dominant concern of many educational institutions, sometimes with the goal being complete campus-wide connectivity, where all computer resources are integrated and accessible to all students, faculty, and administrators. Another goal in network connections is for transparency: easy and invisible access to the required resources, even if it includes complex procedures to communicate with disparate computers.

Long-Distance Networks: Also critical in the evolution of academic computing are networks which connect users and resources over great distances. The University of California and the California State University have developed networks that allow access to computer resources and the exchange of computerized information throughout the university systems. Many faculty are additionally involved in national or international networks, such as Bitnet, which allows communication among colleagues or ways to access computer resources at great distances. Bitnet, the largest computer network serving higher education, has been in existence for seven years. It connects over 300 colleges, universities, and research institutions in the U.S. and abroad, and has a user population of well over a half million.

Computerized Library Resources: Other data communications resources found in educational institutions are sophisticated systems which electronically store and access information housed in the campus library. The University of California's on-line catalog includes all library holdings within the University system and may be accessed from each campus and selected other locations. Many campuses in both university systems are working toward integrating their computerized library resources into campus networks, with the aim of making as many of the library's information resources immediately available through microcomputers to students, faculty and staff at their own workstations. In addition to computerized catalogs of the library's holdings, progress in library automation is resulting in increased access to information through the use of other library's holdings, optical publishing

and external data base access. Libraries are continuing to adopt information technology which makes the dream of instantaneous access to current, intelligently connected, world-wide information more and more possible.

External Databases: Available either through network or dial-up access, external databases of collected information are being increasingly used by educators for research, instruction and administration. The number of public access databases in operation nationwide continues to grow daily. Users access the information stored in the database through their own computer, a modem, and telephone or network lines. An hourly fee is sometimes charged for access. Information stored in data bases usually appears in the form of words or numbers, but there are also data bases whose content appears as digitized sounds or images. One example of an educational database is the California State University's database of comprehensive information about its 20 campuses for high school and community college counselors and potential students. Counselors or potential CSU students can obtain this information by dialing the nearest CSU campus's public access port through their modem and computer, obtaining access to CSUNET, and connecting to the data base located on the CSU Fresno campus. Another example is the University of California's MELVYL system, a database of titles and bibliographic information on all library holdings throughout the system and MELVYL-MEDLINE, an extensive database of medical journal articles. MEDLINE is the first major non-book database the University has made available electronically and has been received with enthusiasm by students and faculty.

Educational Management and Telecommunications: Educational management, like management in other fields, relies increasingly on new computer and telecommunications technologies to access, accumulate and transmit information. Data telecommunications may be used to: compile and transmit attendance, financial information and student profiles; track students' movement across systems of education; integrate services, such as admissions and scholarship awards; and conduct analysis of student characteristics, retention, and matriculation.

Audio/Video Telecommunications

Interactive Distance Instruction: Telecommunications technology is now being used to provide live, interactive instruction to students at distant locations. A televised image of the instructor can be transmitted through a variety of technologies: satellite, microwave, fiberoptic cable, or regular telephone lines. Students at the distant locations com-

municate with the instructor by telephone or a WATS line. Written materials are often transmitted electronically as part of courses taught at a distance. Assignments, tests, papers, and evaluations can be sent back and forth using computer and telecommunications technology. Distance instruction results in increased access to education: students or professionals who might otherwise be unable to participate in education or who would be required to travel distances to get the instruction they desire, can now receive instruction at a location nearby. Business, industry, universities, and schools are capitalizing on the instructional possibilities distance education technology allows.

Teleconferences: One-way video and two-way audio telecommunications can also be used to connect multiple sites for conferences and lectures. The number of students and faculty who can benefit from access to renowned scholars and other guest lecturers multiplies with the use of telecommunications technology.

Telecourses: Telecourses, which have been in use for several decades, are distinguished from regular courses by their alternate method of delivering instruction. Students enrolled in telecourses receive the majority of their instruction for the course via broadcast or cable television. These courses usually consist of series of 30-minute programs which are carefully coordinated with a textbook, a study guide with assignments, and regular contact, either through telephone or in-person, with a college instructor. Telecourses are produced by public television stations, colleges and universities, and private production companies. California Community Colleges have been national leaders in the development and use of telecourses. Coastline Community College and two Community College Television Consortia are leaders in the field, and the majority of the California Community Colleges regularly providing academic credit and support for telecourses.

Supplementary Instructional Television Programming: Supplementary or enrichment programs designed for use in traditional classrooms are primarily made available through public television broadcasts. The programs, used mainly in secondary and elementary classes cover a vast array of subject areas. Designed to a igment the teacher's instruction, the programs use sophisticated graphics, entertaining formats, and on-location filming to present the subject matter. Programs are often videotaped by the instructor or by school media personnel for use later in classes. This type of instructional programming is usually produced for the public television stations with support from government or educational foundation funding. California has been supporting in-

structional programming for elementary and secondary schools through the AB 803 funding.

Digitized Moving Images: The transmission of moving images for entertainment and educational purposes has traditionally been accomplished through the media of film, videotape, and broadcast and cable television. More recent technological developments now make possible the digitization of moving images, their transmission over the same lines as those used for data telecommunications, and their ability to be manipulated and controlled by computers. Educational uses of moving images, such as distance instruction and instructional television programs will be affected by the alternate modes of delivery and manipulation made possible by the digitization of moving images.

Audiographics: Audiographic technology consists of transporting graphics, audio, and data over regular telephone lines to multiple sites. For instructional purposes, the use of audiographics often includes the instructor using an electronic writing tablet that instantaneously transmits the writing to the students' monitors in remote locations. The effect for students approximates being in a classroom and seeing the instructor writing on the blackboard. Combined with two-way audio, so students and teachers can converse, and data transmittal, for the conveyance of assignments or other written material, audiographics technology has been successfully used for long-distance instruction.

References

Berman, Weiler Associates. *Restructuring California Education: Recommendations to the California Business Roundtable.* Sacramento: Berman, Weiler Associates, 1988.

California Economic Development Corporation. *Vision: California 2010.* Sacramento: The Coporation, 1988.

California Postsecondary Education Commission. *Education Offered via Telecommunications: Trends, Issues, and State-Level Problems in Instructional Technology for Colleges and Universities.* Commission Report 87-49. Sacramento: The Commission, December 1987.

Commission for Review of the Master Plan for Higher Education. *The Master Plan Renewed: Unity, Equity, Quality, and Efficiency in California Postsecondary Education.* Sacramento: The Commission, July 1987.

DeLoughry, Thomas. "Professors Are Urged to Devise Strategies to Help Students Deal with 'Information Explosion' Spurred by Technology." *The Chronicle of Higher Education,* 35:26, March 8, 1989.

Joint Committee for Review of the Master Plan for Higher Education. *California Faces . . . California's Future: Education for Citizenship in a Multicultural Democracy.* Sacramento: California Legislature, March 1989.

Martinez, Michael E., and Nancy A. Mead. *Computer Competence: The First National Assessment.* Princeton: National Assessment of Educational Progress and Educational Testing Service, 1988.

National Education Association. *Report of the Special Committee on Educational Technology.* Washington, D.C.: The Association, July 1989.

Office of Information Technology. *Strategic Direction for Information Technology in California State Government 1988-1993.* Sacramento: The Office, June 1988.

Office of Technology Assessment, U.S. Congress. *Power On: New Tools for Teaching and Learning.* Washington, D.C.: Government Printing Office, 1988.

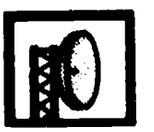
Organization for Economic Co-operation and Development. *New Information Technologies: A Challenge for Education.* Paris: OECD, 1986.

Soviet Education: A Journal of Translations XXIX:9, 10 (July/August, 1987). (Originally published in *Pravda,* March 21, 1987).

Sprecher, Jerry, ed. *Facilitating Academic Software Development.* McKinney, Texas: Academic Computing Publications, 1988.

U.S. Department of Education, U.S. Department of Labor, U.S. Department of Commerce. *Building a Quality Workforce.* Washington, D.C.: Government Printing Office, July 1988.

Young, Luke, *et al.* "Academic Computing in the Year 2000," *Academic Computing,* 2:7 (May/June 1988) pp. 8-12, 62-65.



CALIFORNIA POSTSECONDARY EDUCATION COMMISSION

THE California Postsecondary Education Commission is a citizen board established in 1974 by the Legislature and Governor to coordinate the efforts of California's colleges and universities and to provide independent, non-partisan policy analysis and recommendations to the Governor and Legislature.

Members of the Commission

The Commission consists of 15 members. Nine represent the general public, with three each appointed for six-year terms by the Governor, the Senate Rules Committee, and the Speaker of the Assembly. The other six represent the major segments of postsecondary education in California.

As of February 1990, the Commissioners representing the general public are:

Mim Andelson, Los Angeles;
C. Thomas Dean, Long Beach;
Henry Der, San Francisco;
Seymour M. Farber, M.D., San Francisco;
Rosalind K. Goddard, Los Angeles;
Helen Z. Hansen, Long Beach;
Lowell J. Paige, El Macero; *Vice Chair;*
Cruz Reynoso, Los Angeles; *Chair;* and
Stephen P. Teale, M.D., Modesto.

Representatives of the segments are:

Meredith J. Khachigian, San Clemente; appointed by the Regents of the University of California;

Theodore J. Saenger, San Francisco; appointed by the Trustees of the California State University;

John F. Parkhurst, Folsom; appointed by the Board of Governors of the California Community Colleges;

Harry Wugalter, Thousand Oaks; appointed by the Council for Private Postsecondary Educational Institutions;

Joseph D. Carrabino, Orange; appointed by the California State Board of Education; and

James B. Jamieson, San Luis Obispo; appointed by the Governor from nominees proposed by California's independent colleges and universities.

Functions of the Commission

The Commission is charged by the Legislature and Governor to "assure the effective utilization of public postsecondary education resources, thereby eliminating waste and unnecessary duplication, and to promote diversity, innovation, and responsiveness to student and societal needs."

To this end, the Commission conducts independent reviews of matters affecting the 2,600 institutions of postsecondary education in California, including community colleges, four-year colleges, universities, and professional and occupational schools.

As an advisory planning and coordinating body, the Commission does not administer or govern any institutions, nor does it approve, authorize, or accredit any of them. Instead, it cooperates with other State agencies and non-governmental groups that perform these functions, while operating as an independent board with its own staff and its own specific duties of evaluation, coordination, and planning.

Operation of the Commission

The Commission holds regular meetings throughout the year at which it debates and takes action on staff studies and takes positions on proposed legislation affecting education beyond the high school in California. By law, its meetings are open to the public. Requests to speak at a meeting may be made by writing the Commission in advance or by submitting a request before the start of the meeting.

The Commission's day-to-day work is carried out by its staff in Sacramento, under the guidance of its executive director, Kenneth B. O'Brien, who is appointed by the Commission.

The Commission publishes and distributes without charge some 30 to 40 reports each year on major issues confronting California postsecondary education. Recent reports are listed on the back cover.

Further information about the Commission, its meetings, its staff, and its publications may be obtained from the Commission offices at 1020 Twelfth Street, Third Floor, Sacramento, CA 98514-3985; telephone (916) 445-7933.

TECHNOLOGY AND THE FUTURE OF EDUCATION
Directions for Progress

California Postsecondary Education Commission Report 89-27

ONE of a series of reports published by the Commission as part of its planning and coordinating responsibilities. Additional copies may be obtained without charge from the Publications Office, California Postsecondary Education Commission, Third Floor, 1020 Twelfth Street, Sacramento, California 95814-3985.

Recent reports of the Commission include:

89-10 Out of the Shadows -- The IRCA/SLIAG Opportunity: A Needs Assessment of Educational Services for Eligible Legalized Aliens in California Under the State Legalization Impact Assistance Grant Program of the Immigration Reform and Control Act of 1986, submitted to the California Postsecondary Education Commission, February 23, 1989, by California Tomorrow (March 1989)

89-11 Faculty Salaries in California's Public Universities, 1989-90: A Report to the Legislature and Governor in Response to Senate Concurrent Resolution No. 51 (1965) (March 1989)

89-12 Teacher Preparation Programs Offered by California's Public Universities: A Report to the Legislature in Response to Supplemental Language in the 1988 State Budget Act (March 1989)

89-13 The State's Reliance on Non-Governmental Accreditation: A Report to the Legislature in Response to Assembly Concurrent Resolution 78 (Resolution Chapter 22, 1988) (March 1989)

89-14 Analysis of the Governor's Proposed 1989-90 Budget: A Staff Report to the California Postsecondary Education Commission (March 1989)

89-15 Planning Our Future: A Staff Background Paper on Long-Range Enrollment and Facilities Planning in California Public Higher Education (April 1989)

89-16 Standardized Tests Used for Higher Education Admission and Placement in California During 1988: The Fourth in a Series of Annual Reports Published in Accordance with Senate Bill 1758 (Chapter 1505, Statutes of 1984) (April 1989)

89-17 Protecting the Integrity of California Degrees: The Role of California's Private Postsecondary Education Act of 1977 in Educational Quality Control (April 1989)

89-18 Recommendations for Revising the Private Postsecondary Education Act of 1977: A Report to the Legislature and Governor on Needed Improvements in State Oversight of Privately Supported Postsecondary Education (April 1989)

89-19 Mandatory Statewide Student Fees in California's Public Four-Year Colleges and Universities: Report of the Sunset Review Committee on Statewide Student Fee Policy Under Senate Bill 195 (1985), published for the Committee by the California Postsecondary Education Commission (April 1989)

89-20 State Policy Guidelines for Adjusting Nonresident Tuition at California's Public Colleges and Universities: Report of the Advisory Committee on Nonresident Tuition Policies Under Senate Concurrent Resolution 69, published for the Committee by the California Postsecondary Education Commission (June 1989)

89-21 State Oversight of Postsecondary Education: Three Reports on California's Licensure of Private Institutions and Reliance on Non-Governmental Accreditation [A reprint of Reports 89-13, 89-17, and 89-18] (June 1989)

89-22 Revisions to the Commission's Faculty Salary Methodology for the California State University (June 1989)

89-23 Update of Community College Transfer Student Statistics, 1988-89: The University of California, The California State University, and California's Independent Colleges and Universities (August 1989)

89-24 California College-Going Rates, Fall 1988 Update: The Twelfth in a Series of Reports on New Freshman Enrollments at California's Colleges and Universities by Recent Graduates of California High Schools (September 1989)

89-25 Overseeing the Heart of the Enterprise: The Commission's Thirteenth Annual Report on Program Projection, Approval, and Review Activities, 1987-88 (September 1989)

89-26 Supplemental Report on Academic Salaries, 1988-89: A Report to the Governor and Legislature in Response to Senate Concurrent Resolution No. 51 (1965) and Subsequent Postsecondary Salary Legislation (September 1989)

89-27 Technology and the Future of Education: Directions for Progress. A Report of the California Postsecondary Education Commission's Policy Task Force on Educational Technology (September 1989)