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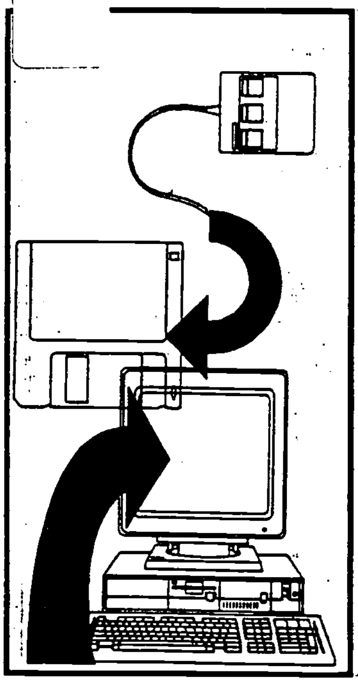
ABSTRACT

This report presents an overview of some of the major issues facing California higher education as it moves into the Information Age. It reviews previous California Postsecondary Education Commission reports on educational technology back to 1979, noting the changing emphasis of those reports from a preoccupation with distance learning to a broader consideration of technology's effects on all aspects of campus life. The report provides descriptive summaries of the ways in which the California Community Colleges, California State University, and University of California systems have incorporated technology in their regular operations, especially in regard to connectivity and infrastructure, teaching and learning, administration and student services. It also examines the possible effects of new technological delivery systems on student learning, particularly in regard to distance education. Three appendixes provide a glossary, a short primer on the Internet, and examples of technology and telecommunications projects being undertaken by California Community Colleges. (Contains 41 references.) (MDM)



COMING OF *Information* AGE IN CALIFORNIA HIGHER EDUCATION

CALIFORNIA POSTSECONDARY EDUCATION COMMISSION

FEBRUARY 1997

COMMISSION REPORT 97-1

Summary

This report is the second in a series on technology in higher education. It follows up on the conclusions and recommendations of the California Postsecondary Education Commission's two long-range planning reports, *The Challenge of the Century* and *A Capacity for Growth*. These 1995 reports projected a major increase in enrollment demand for California's higher education institutions in the context of continuing resource restrictions facing those colleges and universities. The use of technology was one of the primary options mentioned in these reports as a possible way to help address the challenges ahead for postsecondary education in California.

The initial report in this series on technology in postsecondary education, *Moving Forward*, was published in 1996 and discussed the issue of reformed practice brought on by technological innovation. It also surveyed various national and State initiatives like the National Learning Infrastructure Initiative and the Western Governors' proposed "virtual university." Finally, it reviewed recent activities of the California Legislature related to this topic, and some of the innovations presently underway at California State University, Monterey Bay.

Continuing the Commission's focus on higher education technology, this report provides an overview of the various initiatives at the three public systems of higher education, a discussion of technology and pedagogy, and a list of challenges and problems that will be addressed by the Commission in the future. It also contains background information on the Internet and on general terms employed in technology discussions.

The Commission approved this report at its meeting on February 10, 1997, on recommendation of its Educational Policy and Programs Committee. To order copies of this report, write to the Commission at 1303 J Street, Suite 500, Sacramento, California 95814-2938; or telephone (916) 445-7933. This report is available on the Internet. For further information, please visit the Commission's home page at www.cpec.ca.gov. Questions about the substance of the report may be directed to David E. Leveille at (916) 322-7991, William L. Storey at (916) 322-8018, or E-mail bstorey@cpec.ca.gov, or Stacy Wilson at (916) 322-8015, or E-mail SWilson@cpec.ca.gov.

COMING OF Information AGE IN CALIFORNIA HIGHER EDUCATION

A Survey of Technology Initiatives and Policy Issues

POSTSECONDARY CALIFORNIA EDUCATION COMMISSION

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POSTSECONDARY CALIFORNIA EDUCATION COMMISSION

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1 An Agenda for Statewide Technology Planning

THIS REPORT by the California Postsecondary Education Commission presents an overview of some of the major issues facing California higher education as it moves into the Information Age. Many observers of the changes technology is bringing to society have come to believe that those changes will be as profound and wrenching as previous transitions in industrialism, transportation, and media. And, while there is not yet a true consensus on the economic and social relationships expected in 10 to 15 years, there is near unanimity that the need for education can only increase.

> *. . . higher education -- public, independent, and private -- faces the prospect of great change in virtually all of the ways it has conducted its affairs and delivered its services to prior generations.*

There is a similar consensus that higher education -- public, independent, and private -- faces the prospect of great change in virtually all of the ways it has conducted its affairs and delivered its services to prior generations. The time-honored tradition of delivering instruction through lectures, discussions, demonstration laboratories, textbooks, and written examinations is being questioned as never before on the grounds of both efficiency and effectiveness. Such questions appear to be particularly poignant in California at the present time, since it is evident that enrollment demand is growing at the same time that resources are, if not shrinking, then at least unlikely to meet the need as it has been defined traditionally.

That challenging and worrisome equation of growing enrollment demand and restricted resources led the Commission to issue to policy makers its own *Challenge of the Century* last year (CPEC, 1995a), and has led more specifically to this second of three reports on technology in higher education. Following a series of discussions of the issues presented here, a third report will be considered by the Commission and will contain specific conclusions and recommendations that will point to an overall policy and fiscal direction for higher education and technology for the next five to 10 years. Some of those issues -- by no means an inclusive list -- are presented below.

It is not the Postsecondary Education Commission's intent to offer conclusions or recommendations before activating a consultation process this spring and summer to seek advice from the three public systems of higher education, but also from independent and private postsecondary education, and from various other experts in educational technology. That process should culminate in a final report later in 1997.

Throughout this exploration of technology's impact on higher education, the Commission has never lost sight of two central postulates: that technology may represent part of the solution to the evident dilemma of strong enrollment demand and limited resources; and that, even if technology is not as great a part of the answer as may be hoped, California needs to plan nevertheless for a technological future in which education in many forms will play a central role. The exact nature of that role is becoming apparent; a growing cadre of observers appears to be concluding that technology will change almost everything in the lives of almost everyone, and do so not only at work, but at school, at home, and in recreational pursuits. Technology does not just make our actions faster and more efficient, it creates whole new categories of things to do and ways to do them.

This report offers an overview of the technological environment in which higher education finds itself as the next century approaches:

- Chapter Two reviews some previous Commission reports on educational technology, which date back to 1979, and indicates the changing emphasis of those reports from a preoccupation with distance learning to a broader consideration of technology's effects on all aspects of campus life. This chapter also reviews the first of the Commission's technology trilogy, *Moving Forward*, as well as some aspects of the report by the Governor's Council on Information Technology.
- Chapters Three, Four, and Five provide descriptive summaries of the activities of the three California public higher education systems. These chapters are intended to offer a general inventory of current and proposed activities in each system, as well as indicate both similarities and differences in the ways in which each system has proceeded with incorporating technology in its regular operations. In each, the subject of networking dominates, although there is also a discussion of transformation, productivity, and planning issues.
- Chapter Six discusses a controversial subject, the possible effects of new technological delivery systems on student learning. There is a growing body of evidence that such techniques as compressed interactive distance learning, at-home (or anywhere) network teaching, and especially interactive multi-media (delivered through the Internets, or CD-ROM), may be as efficacious to the learning process as more traditional lecture/laboratory/discussion formats, and may also be less costly. Present evidence is not conclusive, but the possibilities are sufficiently tantalizing that numerous higher education institutions are using some of the available courseware now.

Defining a planning agenda

It is a stark reality of modern times that change will occur whether anyone plans for it or not; it may be haphazard, wasteful, inefficient, and even counterproductive, but there is no doubt that it will occur whether guided by reason or left to the randomness of events. The challenge before the State of California, and indeed before the Commission, is to ensure that randomness does not govern public policy, that unnecessary duplication of effort does not dominate higher education's service agenda, and that well-conceived plans make it possible for the next generation of students to be equipped with the knowledge, skills, and perspectives they need to function productively and humanely in the 21st century.

The wisest courses of action are not yet evident. There are disagreements over pedagogy; over the architecture, ownership, and administration of electronic networks; over costs; and over the proper courses for higher education to pursue into an uncertain future. In the coming months, the Commission will seek answers -- through a broad consultation process -- to many of the questions and issues that are posed below. The following list is not inclusive, but provides a starting point -- an agenda -- for further discussion.

1. Networking.

As noted in this report, all three public higher education systems are actively engaged in ambitious projects to network all of their campuses and related facilities, such as central offices. Each of these networks, in turn, will be connected to the Internet, possibly to other networks, and probably to each other. Numerous questions arise from these efforts, including:

a. What are the primary purposes of these networks?

b. Is there a need for a statewide networking plan that will encompass each of the three public systems?

c. Should each system have its own network, or would it be more cost effective to have a single network used by all three systems?

d. What is the useful life span of the networks currently under design and construction?

e. Given the rapid pace of technological change, what may the ongoing costs be of maintaining networks in state-of-the-art condition?

f. Should the costs of maintaining and possibly expanding networks be considered primarily as a one-time capital outlay item, an ongoing support budget item, or some combination of both?

2. What are the educational implications of technology?

As noted in Chapter Six of this report, the possible educational or pedagogical implications of technology are controversial. Some believe there is a major potential for enhanced learning, while others maintain that traditional techniques are best and should be continued. Some think technology, properly focused on specific areas, can be beneficial to the learning process, but that it may not have wide applicability. All of these points of view undoubtedly need to be discussed, with the most modern research on the subject explored fully.

3. Certification, transfer, and accreditation.

The increasing availability of interactive courseware, delivered on computers through either CD-ROM disks or networks, raises questions of certification, transfer acceptability, and ultimately, accreditation. Is a degree or certificate received largely through technological media of one form or another comparable to a traditional program?

4. Will technology require more or fewer resources?

There is no consensus on this question, although some have indicated the probability that there will, at least, be short-run cost increases to purchase equipment, lay fiber-optic cable, and train personnel. Longer term, there are questions of access (distance learning), technological literacy for the next generation of graduates, remediation, use of facilities, and the certification of competencies, all of which have fiscal implications.

5. Will technology affect fee and financial aid structures?

There is a growing discussion of a "facilities fee" in higher education that might help defray the costs of purchasing necessary computers and software, and perhaps providing loans or grants to students who will need notebook computers. There could also be differential fees for students taking courses through technological media such as interactive CD-ROM multimedia courseware, or perhaps taking courses at remote sites. If the pressures of a Tidal Wave II of increased higher education enrollment demand overwhelm the public institutions, will it be necessary to expand student aid programs to divert students to independent institutions or to the proprietary sector?

6. Does technology raise equity and diversity issues?

It is increasingly evident that technological skills will be mandatory elements of almost any resume for any job in the future. It is also evident that there is a strong correlation between economic class and buying home computers, cell phones, and the like. On campuses, the ownership of a laptop (notebook) computer can be a large advantage, as can prior experience operating any of the sophisticated software programs that are commonly available and will probably become increasingly so. Does higher education have the responsibility to close such gaps, perhaps to provide special training to some students whose technological preparation prior to college entry is inadequate, particularly because of economic and educational differences among families? Should there be aid packages to help some acquire technology they could not otherwise afford?

7. The "Virtual University."

The Western Governors' Association is creating the Western Governors' University, a "virtual university" that will certify degrees and competencies largely through distance learning. California has declined to join this effort, but is considering the establishment of a "virtual university" of its own.

a. To what extent should such an effort be supported?

b. Should one or more of the public systems be directly involved?

c. How should such an entity be planned and financed?

8. Facilities standards.

California public higher education has operated under "temporary" space allocation standards for over 25 years. These standards measure physical capacity at any campus by determining the number of students taking courses in classrooms and teaching laboratories. In the Information Age, students in ever greater numbers will be earning credits outside of such facilities, perhaps at home, in self-instructional computer centers, in cyber-libraries, or even in private commercial space.

a. What are the implications of these trends?

b. Should the current space standards be revised?

c. Should new ways of measuring "real" campus capacity be devised?

9. Other facilities questions.

a. Will technology change the architecture of American higher education?

b. Has California built its last traditional library -- all future libraries being, in essence, cyber-libraries with all collections stored magnetically?

c. Will technology obviate the need for more campuses as technology eliminates distance as a factor in learning?

10. Public-private partnerships.

There is evidence that alliances between higher education and the corporate sector, common since the end of World War II, now often provide educational packages that train employees to meet specific corporate standards. Most of these programs are offered on a self-support basis through University of California Extension, California State University continuing education programs, or community college contract education programs. There is also a growing movement within corporations, unknown in extent, to provide their own training. Do these new trends in education and training include issues of public policy that need to be considered? Should the State encourage more public/private partnerships to meet the higher education enrollment demands of Tidal Wave II?

Whatever the future may hold, there is a broad consensus that education will be central to creating and sustaining it.

As noted above, this is not an inclusive list of questions. At the same time, it is probable that planners and policy makers will not resolve even this relatively short list for many years. Whatever the future may hold, there is a broad consensus that education will be central to creating and sustaining it. The questions are who will deliver that education and how? Computers and telecommunications make inconceivable amounts of information available to anyone with a modem, and that accessibility has empowered so many people so quickly that the traditional hierarchies are beginning to dissolve. At a time when the World Wide Web is growing at the rate of two million pages every month, there should be little surprise at the expanding independence of the American people. No longer dependent on traditional purveyors of information and knowledge, some people are designing their own learning paradigms, choosing to learn selectively, sometimes questioning authority -- most authority being based on the exclusivity of knowledge -- and custom designing their lives in ways that were unimaginable only a few decades earlier. For university and college faculty, whose authority and prestige have long been based on the exclusivity of the knowledge franchise, this raises large issues: How important will faculty be when most of what they can offer can be purchased at low cost on a CD-ROM? This represents yet another unanswered but important question.

The challenge now is to continue the discussion of these issues. The Commission noted in 1995, in *A Capacity for Growth*, that planning is not so much a way to predict the future as it is a discipline that permits creative thinking about the future. It is also a way to provide advance warning of problems, to organize data into useful forms, and to encourage consideration of the interrelationships between people and resources. Above all, planning is a dynamic process that should continue indefinitely, adjust for change, and seek new insights. It is with such a mission in mind that the Commission continues to move forward to explore the implications of the Information Age on California higher education.

2 Introduction

THIS REPORT is the second in a series of policy discussions about growth, resources, and technology in higher education that the California Postsecondary Education Commission initiated in 1994, and that will continue during 1997. This ongoing discussion emanated from the recognition that California was entering a period of rapid growth with respect to higher education enrollment demand at the same time that resources were becoming increasingly constrained. Initially, that perception led to a focused exploration of the factors involved, and produced *The Challenge of the Century -- Planning for Record Student Enrollment & Improved Outcomes in California Postsecondary Education* (CPEC, 1995a). *The Challenge*, as it has now come to be known, presented State policy makers with 24 recommendations on California's tax structure, a long-term student fee and financial aid policy, instructional efficiencies, the improvement of quality, and enhanced program integration with the public schools. The report also suggested that the responsibility for the maintenance and improvement of a high quality educational system did not rest with one group, but was the collective responsibility of:

- students -- who must prepare themselves academically;
- families -- who must instill a love of learning;
- voters and their government -- both of which must demonstrate a commitment to education by providing an investment in necessary resources;
- employers -- who need to cooperate with educators to clarify expectations; and lastly,
- the institutions of higher education -- these must operate efficiently and provide a quality educational environment.

During the discussions that produced *The Challenge*, the Commission and others came to believe that most of higher education's problems were solvable, provided the political and institutional will could be mustered to face them honestly, and indeed fearlessly. Solutions in the area of capital outlay, however, appeared to be particularly intractable, and the Commission accordingly directed its staff to conduct a comprehensive examination of the problem. That led, in August 1995, to publication of *A Capacity for Growth* (CPEC, 1995b), a report that included detailed enrollment projections, a statewide survey of institutional capacity, a projection of the State's economy and State General Fund revenues, and an analysis of capital outlay needs through the year 2005-06. A discussion of two related issues, the future of Proposition 98 funding -- an issue of particular importance to California's community colleges -- and a projection of State bonded debt, both of which are crucial to an understanding of the facilities problem, were appended to the report.

Overall, the conclusions offered in *Capacity* suggested that the problem of strong enrollment growth demand in concert with unprecedented resource restrictions could probably be solved on the operations side of the budget, provided the State did not diminish its commitment, and the economy continued to improve. Capital outlay, however, posed a major dilemma, as the Commission noted:

> . . . the Commission can find no combination of practical possibilities that would produce savings or revenue sufficient to satisfy the total (capital outlay) need. Under the best of circumstances, it may be possible, through strong local efforts from community college districts, greater fund raising by the two university systems, the passage of bond issues, and more efficient operation, to raise about half to two-thirds of the needed funds (p. 10).

Perhaps because of *Capacity*'s challenging conclusions, the Commission expected the report to be criticized, perhaps on the grounds that the enrollment projections were too high or the finance projections too low. However, no serious critiques emerged. The University of California did suggest that the projections for its system were slightly exaggerated, and that most of the enrollment surge would occur after 2005, while *Capacity* indicated that the major growth surge would be between 2000 and 2005. Yet, subsequent revisions in the University's own projections, together with further analysis by the Demographic Research Unit of the Department of Finance, have brought the University's numbers closer to the Commission's original projection. There is, therefore, a substantial consensus within the policy community that the Commission's forecast for the next 10 years is substantially accurate. Further, various reviewers from policy oriented research entities in the private sector have substantiated the Commission's enrollment projections and its capital outlay analysis. Given that, the focus has shifted away from an emphasis on defining the problem analytically to the question of prudent and necessary actions to address it.

Some of those potential actions, 13 in all, for closing the resource gap were discussed in *A Capacity for Growth*, with a special emphasis on seven that appeared to warrant further study. The other six options were abandoned either because they raised little money, were narrow in their applicability (e.g. Mello-Roos districts), or were certain to be too unpopular to be seriously considered (e.g. tax increases, the diversion of funds from other programs, a student facilities fee). The remaining seven, however, included such possibilities as selling bonds, diverting students to independent institutions, extending summer terms, improving student flow, and increasing use of technology. Since some of these options were well known (e.g. bond sales), while others had been tried before without noticeably beneficial results (e.g. year-round operations), attention turned to technology as a possible way to transform California higher education and create greater efficiencies that will help to close the enrollment/resource gap. This led to the current study, which continues one of the Commission's major interests over the years.

The three main purposes of this report are: (1) to present an overview of the activities of the three public systems of California higher education with respect to technology; (2) review current issues of pedagogy and technology, and the ability of technological systems to deliver high quality education; and (3) identify a number of crucial current and long-term policy issues facing California's leadership. Rather than attempt to resolve those issues now, the Commission intends that this report establish a framework for discussion that will bring some focus to a highly complex subject.

Previous Commission technology reports

The Commission is no stranger to the analysis of technological applications in higher education. Since 1979, the Commission has reported on such subjects as the use of instructional media on campus (CPEC, 1979), telecommunications and distance learning policy (CPEC, 1981, 1987, 1991), and general technology policy (CPEC, 1989). Initially, most of the Commission's attention was directed to distance learning, since most policy makers in the 1970s and 1980s were concerned with expanding access to underserved populations who did not reside near a public college or university. In the late 1980s, however, this orientation began to shift to other considerations as the Information Age gathered momentum, and technological applications, particularly networks and multi-media, became more widespread.

In 1989, the Commission published *Technology and the Future of Education: Directions for Progress*, which discussed technology's unrealized promise, its (at the time) quite limited uses, a few national and statewide efforts, and barriers to expanded usage. It also offered 14 recommendations, some of which remain timely. The report's introduction offers an overview:

> . . . (there is a) 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 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 (p. 3).

Today, the basic agenda in that 1989 report remains almost unaffected: technology is still evolving rapidly, there is still tremendous population and enrollment growth, demographics continue to change, the need for a well-educated workforce is probably greater than ever, and it remains true that technology alone will not solve all of higher education's problems and challenges. In at least these respects, very little has changed.

In other respects, change has been swift and daunting. The 1989 report said almost nothing about the Internet, which at the time was poorly understood and little used by today's standards, even though it had been in existence since 1969 (see Appendix B). Today, the Internet is bringing the world, and higher education, close to the dream of ubiquitous networking that will interconnect the world. The other great change is usually referred to as "transformation," a new way of doing business, which is discussed briefly below and referred to throughout this report. In the late 1980s, when resources were not as constrained as they are today, the Commission discussed technology within the context of improving access and quality, of giving students the tools they would need to function effectively in the 21st century. Today, while access and quality remain high priority concerns, the focus may have shifted to maximizing resources (i.e. doing more with less).

Even with those limitations the 1989 report highlighted a number of issues that remain relevant. For example, it noted that while the future would be dominated by technologically proficient "knowledge workers," technology is not as widely available in the public schools as it should be. It also suggested that the "future of technology in education is no longer a highly speculative exercise" (p. 11). Specifically, the report offered seven recommendations that pointed to a future that has probably turned out to be less certain than the optimism that the late 1980s implied. In almost every case, these recommendations read like generalities, and they suggest that the conventional wisdom of the time was not clear as to the real role technology might play in the coming decades. The report spoke to the ideas that every student should have access to a computer, that distance learning should be expanded, that some learning in the future might involve interactive computer programs, that networks would expand, and that technology should permit closer ties to the business community. The sixth recommendation in particular is illustrative, and just as relevant now as then to the discussion of technology:

> 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 the solution (p. 14).

The report concluded with a call for coordinated planning among educators, State government, and the corporate sector. It stated:

> 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 . . .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 (p. 15).

In the ensuing five years, and no doubt due to the unprecedented budgetary crisis California faced, technology's potential contributions to higher education have gone largely unrealized, as has the issue of intersegmental coordination. There have been numerous local initiatives, as will be discussed in Chapters Three, Four, and Five of this report, but it is clear that an overall State plan or vision has not emerged. It is entirely possible that such a grand design is neither possible nor desirable; not possible because the combination of technological complexity and differentiation of function suggests unique approaches in each educational system, and not desirable because comprehensive statewide direction might well stifle the institutional creativity California is trying to encourage. Yet, the Commission is convinced that a statewide vision for the use of technology will not efficiently come into fruition absent coordinated planning and focused resource allocation consistent with such a vision or plan.

The Commission's recent report, "Moving Forward"

Recently, with the fiscal crises of the first half of this decade seemingly in the past, with many striking new developments in networking, much faster and more powerful computers, the explosion in interactive CD-ROM technology, and a host of other technological innovations, the Commission has undertaken a new assessment of the role technology should and will play in higher education teaching, research, and public service. The first of these assessments was entitled *Moving Forward* (CPEC, 1996), which dealt primarily with three subjects: "The Call for Transformation," national technology initiatives, and some statewide activities, including recent legislation and the development of California State University, Monterey Bay.

Moving Forward traced the migration of the technology agenda that began with distance learning in the 1960s and 1970s, moved to a broader and less focused interest in computers and telecommunications in the 1980s, and is now focused on universal networking, virtual learning, and the transformation of academic procedures, including the way courses and programs are taught. At one time, it was hoped that the introduction of computers, in concert with satellite transmissions and telephone networking, would automatically expand access and create broadscale efficiencies in public higher education. Today, most observers are coming to a different conclusion -- at least in the short run, technology will probably require more, not fewer, resources, and that any savings will come about not just as a result of the introduction of technology, but from the application of technology to reformed administrative procedures and academic formats. As *Moving Forward* suggested, when the question of serving more students with the same or fewer resources is considered, it is probably true that, while technology is not the sole answer, we cannot get to the answer without technology. Put another way, higher education is being required to find new ways of doing business that probably will create efficiencies, but those new human behaviors will not be possible without technological applications of many kinds. Faculty, students, administrators, alumni, and the general public will all be asked to "transform" what they do, but none of that transformation will be possible without the use of everything from computers to networks to cell phones to satellites.

The Governor's Council on Information Technology offered much the same sentiment in its report *Getting Results*:

> By using information technology not just as a tool, but as a catalyst for a reassessment of mission and a resetting of goals, government has an enormous opportunity to bring home these rewards -- and get results. This is why, in spite of the Council's name, this report is not a testimonial to modern technology. It is a call to action for government to re-engineer itself with a focus on improving outcomes. And, it is about some of the ways that information technology can help" (p. 1).

This transformation -- which might be defined as both a new way of doing business and a new way of seeing the world -- will require higher education to bring about behavioral and perceptual changes. *Moving Forward*, as well as an earlier Commission report on the university of the 21st century (CPEC, 1993), included sections that discussed transformation in some detail. Among the observations in both reports was the premise that technology does not just make difficult tasks easier, it changes the way people perceive reality, and hence the way they behave. In higher education, it is changing expectations of the ways by which education should be delivered -- from the traditional lecture/laboratory format to a variety of formats that are not bound by set times and places, but can be delivered through television and computers connected to satellites and ground-based networks that provide both a graphic and textual window to much of the rest of the world.

. . . students increasingly believe themselves to be empowered to find their own information and knowledge from a wide array of freely available sources such as the Internet or CD-ROM programs. This is creating a "fusion" of learners and learning systems.

Yet technology will probably do much more even than that. It is also changing the perception of a linear world in which events, authority structures, and learning follow in predetermined paths and hierarchies. No longer content to see the professor as an authority figure from whom one gathers all relevant information and knowledge, students increasingly believe themselves to be empowered to find their own information and knowledge from a wide array of freely available sources such as the Internet or CD-ROM programs. This is creating a "fusion" of learners and learning systems. There is the additional perception, strongly reinforced by an economic structure that is increasingly fluid and transitory, that education must continue throughout life in a kind of perpetual college, with students of all ages stepping into the educational system to acquire specific skills or even complete a comprehensive retraining regimen.

Moving Forward discussed these matters briefly, and also discussed transformation's first cousin, productivity. Given the coming equation of strong enrollment growth matched with limited resources, it will be imperative to find new ways to use resources efficiently. Certain, as was noted in the June report, is that:

> . . . change is inevitable, and that it will occur regardless of whether people take definitive steps to direct it. Indeed, the failure to decide is in itself a decision . . . . The growing technological revolution is creating -- and to a degree has already created -- an Information Age that offers innumerable possibilities for changing the way people learn, live, and work (p. 29).

Those two themes of technology and transformation -- together they might be termed the productive management of inevitable change -- permeated through most of *Moving Forward*, and will carry through this and subsequent reports as well. As will be noted repeatedly, change itself is not a choice, since it will happen whether directed or not; the challenge is to direct it to the greater good.

Independent and private postsecondary institutions

There is no doubt that technology has had an impact on independent and private postsecondary institutions at least as much, if not more, than the three public systems of postsecondary education in California. A growing body of anecdotal evidence suggests that some of the most innovative administrative techniques, academic programming, and student services operations are to be found in the non-public sector. In many cases, private institutions are offering students highly flexible calendars, open-entry/open-exit course schedules, evening and even 24-hour a day class offerings, on-line registration, and even entire courses through electronic media, including the Internet. The cost for such services is high by the standards of public institutions ($300 to $400 a unit is common), but the flexibility of the offerings provides a valuable service to students who are unable to conform to the more set schedules of the public sector.

The Commission has stated its conviction often that the independent and private institutions are likely to play a large role in meeting the challenges of the "Tidal Wave II" of increased enrollment demand. The *Challenge* noted that the independent sector alone might be able to accommodate another 20,000 students if sufficient financial aid resources could be found. The exact number of additional students that might be educated in the private and proprietary sectors is unknown, but it is certainly in the tens of thousands. Many of these students will receive, at least, a part of their education through technological applications of one kind or another.

Early in 1997, the Commission will convene a technical advisory committee to discuss the issues listed in the first chapter of this report. As that committee is being formed, the Commission will ask leaders in the private and independent sectors to help develop a policy agenda to be discussed later in the year. Much of this discussion will concern technology and its applications, but as will become apparent throughout this report, the issues of technology, productivity, academic quality, and student access are difficult to separate into well-defined categories. Education, and the tools and techniques used to deliver that education, have always involved symbiotic relationships. It will be no different as the possibilities of technological delivery systems are more fully explored.

A word concerning terminology and the Internet

Any discussion of technology in higher education, or just technology in general, involves a host of terms that are not easily recognized nor understood. These include such acronyms as ATM (Asynchronous Transfer Mode), SMTP (an E-Mail term that stands for Standard Mail Transfer Protocol), HTTP (HyperText Transfer Protocol), SMDS (Switched Multimegabit Data Service), and a host of others. To assist the reader of this report, Appendix A contains a glossary of many of the commonly used terms in this confusing field of endeavor. Appendix B is a discussion of the Internet, a much discussed, increasingly used, and rapidly expanding world-wide electronic network. It discusses the Internet's origins, early uses, and current prospects.

3 The California Community Colleges: Education and Technology in Process

Introduction

The California Community Colleges (CCC) comprise the largest college system in the world as well as the largest training network, with 106 colleges, 71 separate districts, 1.4 million students, and a $3.2 billion budget. In fact, 10 percent of all college students in the United States attend a California community college. The community colleges also serve as the point of initial entry for the majority of Californians who pursue postsecondary education, requiring only the possession of a high school diploma or being 18 years old. The combination of open access and local autonomy, discussed below, present complex challenges to the community colleges as they labor to find ways of accommodating increasing numbers of students.

The California Community Colleges are coordinated by an appointed Board of Governors through an administrative Office of the Chancellor. Governance of the colleges, however, resides with elected Boards of Trustees for each of the 71 college districts. This local autonomy has uniquely positioned the colleges to tailor their educational and training opportunities to the needs of the local communities in which they reside. At the same time, it has proved to be an impediment to effective systemwide planning.

At precisely the time when resources are most restricted, it appears that the community colleges will have the greatest needs in their history. The combined forces of strong enrollment demand and limited resources may place unprecedented pressure on the tradition of open access to California Community Colleges. Using conventional standards, a projected increase of 338,000 new students to the system by 2005 would necessitate the building of five to 10 new colleges and educational centers. Therefore, continuing business as usual (i.e. using traditional modes of delivering instruction) in the community colleges may have serious implications for the State and for future generations of students, since space is predicted to be in short supply, and because many of those currently attending a community college are among the poorest, most diverse, and least prepared for higher education of all Californians.

While there is no single solution to the challenge before the State and the California Community Colleges, technology and telecommunications may offer at least a partial resolution to the dilemma. Although collectively the community colleges are not sufficiently well financed to take immediate advantage of the many technological solutions available in the marketplace today, a select group of colleges has been in the forefront of the Information Age as it applies to incorporation of technology in postsecondary education. Unfortunately, the colleges' inability as a system to embrace technology and telecommunications has caused a widening gap between the "have's" and the "have nots," as well as a diminished expectation for major systemwide productivity increases.

Moreover, unlike the Constitutional flexibility provided the University of California or the increased management flexibility provided to the California State University, the California Community Colleges remain entrenched as an agency within State government. This status hampers the ability of the Chancellor's Office to access Proposition 98 funding -- which serves as the basic funding mechanism for community colleges -- to carry out its administrative and coordinating functions, even during a period of economic and campus expansion. The implications for the California Community Colleges in general, and for its use of technology in particular, are significant. While other systems of higher education in the State have progressively gained greater flexibility and increased responsibility to improve effectiveness and efficiency in the face of reduced resources and growth in demand, the California Community Colleges have been heavily entrenched in governmental and bureaucratic minutiae and a regulatory environment that continues to have a negative impact on the system's ability to fulfill its mission.

While State agencies maneuver for control of the various aspects of the State's telecommunications and information systems or argue over the nature of the need, the California Community Colleges languish under regulatory constraints that are inconsistent with its academic mission. Additionally, current budget allocation mechanisms hamper the efficient and effective operation of this large and complex educational enterprise.

Planning for technology in the community colleges

Poised to take advantage of the Information Age in order to better fulfill its mission of education through increased use of technology and telecommunications, the California Community Colleges have initiated a strategic planning process. This process has incorporated the needs of the system and individual districts statewide and has a primary focus on establishing fundamental infrastructure needs and minimum requirements for interconnectivity throughout the system. Yet, absent the necessary resources to design, build, and implement the prerequisite infrastructure, the system will increasingly be on the fringes of the Information Age rather than an integral component of it in California.

The California Community Colleges are an important link in the chain of education, training, and services needed by a growing number of learners who face a future in the workplace and society-at-large that will require increasing levels of knowledge and skills. Like other institutions of postsecondary education, the creative use of telecommunications and information technologies can help the community colleges meet these new enrollment demands and learning requirements while reducing the need for bricks and mortar. Potentially, technology can help colleges accommodate increased enrollments; enhance, enlarge, or modify academic programs; facilitate interactive learning through video-conference presentations or other creative means of technology use; and reach and teach more learners in a wide range of settings and at times that are more conducive to the learners' needs. Because it will take money, particularly in the short term, to underwrite the necessary equipment and systems, cost containment becomes a focal point.

"Choosing the Future: An Action Agenda for Community Colleges"

As recently as five years ago, the Board of Governors initiated a study of alternatives to address future needs of the California Community Colleges by establishing a Commission on Innovation (COI). In November of 1991, the California Community Colleges' Board of Governors formed an independent panel of citizens to identify ways and means by which the California Community Colleges could better address the growing fiscal crisis as well as ways to become more efficient and effective.

The planning milieu in which the community colleges found themselves was a prolonged economic slump facing the state as a whole.

The planning milieu in which the community colleges found themselves was a prolonged economic slump facing the state as a whole. This fiscal crisis had a direct impact on the ability of the colleges not only to remain viable as an integral gateway to higher education and a bridge to educational and employment opportunities for many potential learners, but also on the ways by which the system could better contribute to the lifelong learning needs of an educated workforce and citizenry well into the next century. As succinctly stated in the Commission's November, 1993 report, *Choosing the Future: An Action Agenda for Community Colleges*, its charge was "to recommend how a better job could be done for more students without relying on more funding."

In the innovation commission's report, the recommendation was made to develop a "pervasive technological infrastructure at and between colleges to equip them to increase productivity, enhance management efficiency, and become a premier institution for the application of technology to learning." Among the report's significant conclusions and recommendations was a substantial focus on the use of technology and telecommunications not only relating to instructional uses, but on ways in which the new technologies could and should be used to improve productivity, contain costs, and contribute to systemic changes in the ways that colleges conduct business and fulfill their mission.

Several common themes can be identified in almost all reports and discussions relating to the California Community Colleges and its use of technology and telecommunications:

Systemwide Planning - there has been little systemwide planning and coordination, resulting in an unevenness in technological expertise and capacity within the system and its respective colleges.

Managerial Flexibility - while the size of the community college budget is substantial, the systemwide office has little or no ability to redirect resources to priority areas, such as technology or telecommunications, due to the preponderance of regulations or policies that inhibit management flexibility or leadership in this important area.

System Capacity - the governance and management structure of the community colleges is such that the leadership of the community colleges is thwarted in its efforts to lead and coordinate new directions or is encumbered with "turf issues" that impede rapid adoption of new technologies, common protocols, and policy priorities.

Size - since so much of the funding of the community colleges is based on enrollment, and costs for the necessary technological infrastructure is more often than not based on economies of scale, small institutions are often not able to provide the necessary investment for baseline infrastructure needs (wiring, facilities, software, equipment).

Professional Expertise - while there may be several areas of strength on any given college campus as far as creative use and application of technology is concerned, the fact remains that there is a need for more expertise and its continued renewal on a larger scale throughout the system.

Strategic telecommunications plan

In May 1995, the Chancellor's Office staff, with the assistance of a grant from the United States Department of Commerce, retained the services of a consultant group to assist in development and implementation of a telecommunications planning process. A series of analyses and discussions was conducted throughout the State, culminating in an October 1995 conference, that included almost 200 individuals representing 79 colleges and representatives from State agencies, business, industry and other sectors to discuss a systemwide Telecommunications Strategic Plan.

A set of general principles was considered critical to any further implementation of the Strategic Telecommunications Plan, once it was adopted. Those principles, noted below, are that:

- All strategies consider as part of their critical criteria the immediate impact and ability to support the instructional mission of the community colleges;
- The System advance a vision of a telecommunications infrastructure that defines its goals clearly, that can create an infrastructure in stages, that is built on a foundational principal of rapid (T-1) Internet access through CSUNet (the State University's comprehensive and integrative telecommunications backbone that provides Internet access and links all 22 CSU campuses, many off-campus centers, and over 100 universities, community colleges, public libraries, and public schools), and that will ultimately allow for the full deployment of an advanced systemwide telecommunications infrastructure which is designed to facilitate the seamless transmission of voice, video, data and image;

- The Chancellor's Office role be one of coordination, primarily aimed at mitigating issues of equity across the system, thus ensuring basic levels of access for all colleges, maximizing economies of scale and assuming leadership in the establishment of uniform standards to ensure comparability and compatibility across institutions systemwide;
- Any infrastructure consideration be designed to build on existing networks, where applicable, in order to maximize State resources already invested (i.e., CSUNet);
- Any efforts undertaken to expand the uses of technology address the ability of each college to connect with the greater community; and
- Any applications address and explore the means to leverage compatible resources, including private and public funds.

Emanating from the studies, discussions, and related telecommunications planning activities, the Board of Governors decided to submit a Budget Change Proposal (BCP) for the 1996-97 fiscal year seeking financial support for three areas of activity:

1. The development of a technology (networking) infrastructure;
2. The establishment of demonstration projects to test the deployment and feasibility of key related applications; and
3. The establishment of a coordinating role for the Chancellor's Office to provide leadership and a collaborative vision for the system.

The 1996-97 budget provides $9.5 million funding for the California Community Colleges' Strategic Telecommunications Plan (STP). While this is insufficient to fully implement the plan, even in its initial stages, it represents an important initial investment in community college efforts to expeditiously move their technology and telecommunications capacity forward.

Connectivity and infrastructure development

As part of the BCP review process, the community colleges were able to convince the State to authorize supplemental funding to its base "to assure that each of the 125 sites [of the California Community Colleges] have established necessary infrastructure capability for teleconferencing, connections to CSUNet and satellite downlink" capabilities. The intent of the appropriation was to begin electronic connection of the 106 colleges and district offices to the CSUNet.

The Board of Governors has identified the following near-term benefits it anticipates accruing to the system through an integrated linkage to the California State University's existing network, CSUNet:

- coordination and collaboration with the State University;
- reduced duplication of effort;
- containment of costs; and

- the construction of a sophisticated infrastructure for every college in the system.

Additional educational and administrative benefits that may eventually accrue to the colleges from the funding of this BCP include:

- enriched instructional resources through the Internet;
- delivery of distance learning instructional programs to remote locations;
- utilization of distance learning systems to help address high enrollment and high-demand courses;
- enhanced collaborative interaction between the two systems (the State University and the community colleges);
- enhanced faculty collaboration through electronic mail and discussion groups, quite probably intersegmentally as well as among community colleges;
- electronic transmission of student transcripts;
- computerized access to official course and articulation information to facilitate transfer;
- more efficient development and access to accountability and outcomes data to facilitate institutional improvement;
- improved access to information at all levels in support of shared governance; and
- lower cost of shared information.

In response to the funding allocation, the CSUNet will be expanded from 35 to 160 T-1 circuits to accommodate the needs of the 125 community college sites. To initiate this expansion, the State University and the community colleges have developed a Memorandum of Understanding (MOU) to create the California State University and the Community College Network (C-3Net). Implicit in the nature of that MOU, but independent to it, is an affiliation agreement that every community college district or institution must execute separately. This is in the form of C-3Net Affiliate Subscription Agreement. The C-3Net will be operated under a joint-powers agreement between the Chancellor's Office of the California State University and the Chancellor's Office of the California Community Colleges.

The C-3Net will be connected by high speed, broad bandwidth fiber optic cables capable of carrying a large volume of digital voice, video and data information. As a result, the C-3Net will provide for fully interactive teleconferencing, distance learning, and other video applications. Although video will be limited at first, it will be accelerated in the short term using the advanced Asynchronous Transfer Mode (ATM) and Synchronous Optical Network (SONET) protocol systems.

The function of the C-3Net is to engineer, maintain and operate telecommunications network facilities for: (1) the primary benefit of the C-3Net membership and (2) secondary benefits accorded to the State and national educational and research communities associated with the C-3Net members. The technology applies high-performance inter-campus networking resources supporting educational programs and services, institutional functions and initiatives, and scholarship activities. C-3Net provides access to a wide range of general and unique information resources. In addition, C-3Net supports opportunities for collaboration that facilitates student, faculty and staff communication, development, productivity, and achievement by interconnecting its affiliate members, the Internet and the World Wide Web (WWW).

A Budget Change Proposal for 1997-98 has been submitted requesting an additional augmentation of $14 million to continue the development of technology initiatives and applications to support students, faculty and staff. If approved, the augmentation will provide a total of $23.5 million in the community colleges operational budget (including the previously noted $9.5 million appropriated for 1996-97) to support the intra-college telecommunications connections; refine applications in distance education, student support services, and administrative uses; and support the maintenance of efforts in the training of faculty, students, and staff.

Finally, within the Chancellor's Office of the California Community Colleges, there has been an organizational change commensurate with the prioritization of the strategic technology initiative. An Instructional Resources, Technology, and Strategic Planning Unit, under the leadership of a dean, will provide focus to several functional tasks and responsibilities associated with technology and telecommunications. A similar organizational change has occurred relating to the interim assignment of the Management Information Services (MIS) unit to the Vice Chancellor for Policy Analysis and Development.

Teaching and learning initiatives

A few examples of technology and telecommunications projects in the community colleges are presented in Appendix C. These include consortia and distance learning arrangements, affiliations with public broadcasting stations, an example of technological applications in one large district (Bakersfield), and an overview of administrative applications. Obviously, this is not intended to be an inventory of all community college activities -- such an inventory would almost certainly be obsolete the moment it was printed -- but an indicator of the state of the technological arts in the community colleges. As the systemwide telecommunications plan takes shape, however, and as additional resources are provided, it may be useful for the Chancellor's Office to provide policy makers with a more comprehensive survey.

Change is always difficult, but the evidence of resistance to change is often most compelling in the case of faculty. A major barrier to overcome has been the approach of faculty members who have traditionally served only on-campus students, and who honestly believe that the only legitimate way to teach is through face-to-face instruction. In all probability, it will be the students who will be most effective in bringing about a change, for they are often the ones most conversant with technology, most ready to employ new forms of technology in their lives, and most ready to persuade their faculty mentors that they can learn just as effectively through distance learning, multi-media, and the Internet as they can from traditional means.

As faculty attitudes change and they come to accept educational technology delivery systems, professional development will become crucial. Even faculty who want to try the new forms of instruction will need to be trained in the most effective use of technological tools. This will doubtless require additional funding, but as everyone associated with the quality movement in industry is well aware, training costs little in the long run; it is only the lack of training that is expensive, since it permits employees to remain less efficient and less productive than desired or needed.

Administrative and student service initiatives

It is clear from the initiatives taken so far that the community colleges are attempting to change from "business as usual" procedures and thought processes. However, because they have started late, they have a long distance to travel. The late start has exacerbated their problems, yet it has also afforded them the luxury of observing the actions of others, and thereby choosing better courses of action than might otherwise have been possible. A number of the issues that confront the community colleges as they chart an uncertain future in the Information Age -- where student learning is not limited by time or place -- include the following:

- Student Services: Success in attracting, serving, and retaining students will be dependent more on excellent student support services than on technology issues. Yet, it will be necessary to define ways by which effective support services can best be provided to students who choose to complete most, or all, of their education at a distance from traditional campus-based services.
- Access (Internet/Electronic Mail): An important consideration for many students and the institutions that serve them is access to the Internet and electronic mail. Inaccessibility to the Internet and electronic mail has proven to be a barrier in rural areas and, when it is available, the costs are exceedingly high.
- Access (Equipment): For students facing primarily a distance learning opportunity through computer-based technology, a barrier for many is a lack of "cross-platform capability" between Macintosh and DOS standards.
- Student Training: Although students are in many instances very familiar with technological advancements, the fact remains that there is a need for student training on the institution's media and technology system which is integral to a successful experience for students and the institution alike.
- Resource Sharing: Given the large number of community colleges and their diversity in both resources and size, the potential for technology to enable colleges to share expensive instructional support equipment and intellectual resources

with other public and independent colleges in the state is significant. Focused attention in this area may yield tremendous benefits to the colleges -- and the State -- in terms of curricular breadth, course articulation, and cost containment.

- Facilities: With community colleges facing the greatest demand for physical expansion in the near future, building design for the Information Age will be a critical element in future planning. Both new and renovated buildings will have to be designed with networking and computers in mind, and with a flexibility that will permit new modes of instruction to be accommodated easily.

Summary

This chapter of the Commission's report has discussed a number of the challenges facing the California Community Colleges in the area of technological innovation and change. A good planning foundation has been laid -- through the adoption of a systemwide Strategic Telecommunications Plan -- that will doubtless solidify in the near future. The choice of the components that are then placed on that foundation will represent a challenge not only to the system, but to each of the 106 colleges.

As noted earlier, change will occur whether planned or not. Good planning and realization of the full potential technology offers to the community colleges will require prudence, intelligence, and resources. Thus far, while it is plain that the requisite prudence and intelligence are being brought to bear, it is not clear that the necessary resources are, or will be, available in a timely manner in the near future.

That fact alone suggests the need for a new compact between the Board of Governors and the State of California. The historic practice of treating the Board and its staff as a conventional State agency may not function in the efficiency-centered, entrepreneurial environment that is rapidly replacing the old risk-avoidance and regulatory reality. Even though it is in the State's interest for the Board to move expeditiously with implementation of its strategic technology initiative, and while the Chancellor's Office is accountable for its implementation, no State funds are allocated to underwrite the administrative responsibilities of the Chancellor's Office in the implementation of the initiative. The arguments that resources within the Chancellor's Office can be reassigned and that priorities can be rearranged, particularly for an agency that has lost nearly half of its funding in the past five or six years, are not persuasive.

As the community colleges move forward with their plans for a technological future, the Commission will take a continuing interest in all of the issues noted in this report, as well as new issues identified by its staff or others monitoring technological advances. The degree to which those issues are ultimately resolved will, to a large extent, determine the quality of instruction available in community colleges for years to come. It will also have a major bearing on the ability of the community colleges to meet new workforce needs of recent high school graduates, current workers seeking new skills, and welfare recipients seeking initial or new skills for entry into the workplace.

4 Technology Initiatives in The California State University

Introduction

The California State University is comprised of 22 campuses serving more than 330,000 students throughout the State and is one of the largest public university systems in the nation. Systemwide governance of the State University resides with a gubernatorially appointed Board of Trustees, while the day-to-day administration of the system is handled by the systemwide Office of the Chancellor in cooperation with campus presidents. The California State University's mission gives it primary responsibility for teacher preparation and authorizes degree programs through the masters level. Nearly two-thirds of all California teachers employed in public schools received their education and training from a State University campus. Freshman students admitted for study in the State University are selected from among the top one-third of high school graduates and more than 60 percent of its new students annually transfer in from a local community college or other baccalaureate degree-granting institution.

The California State University has established a national reputation as a pioneer and leader in the promotion and application of advanced telecommunications and technologies to support its mission of affordable access to quality educational programs. During the period 1963 to 1993, the State University built two new campuses, added seven off-campus centers, and, through the effective use of emerging telecommunications, constructed a systemwide network (CSUNet) complete with video-conferencing and satellite uplinks and downlinks that allowed it to accommodate a nearly 150 percent increase in enrollment while maintaining educational quality. In addition, 1.5 million State University graduates entered the labor force and contributed to the State's economy.

The first half of the present decade, however, has been difficult for the CSU because of the State's recent recession and declines in fiscal support for public higher education that resulted from it. Between 1990 and 1993, general fund appropriations to the State University fell by about three percent per year, from approximately $1.65 billion to $1.45 billion. The system also recorded a backlog of about $400 million in deferred maintenance. To partially compensate for limited State support, annual undergraduate student fees were increased by about 75 percent during the above period, making access less affordable for many Californians. This contributed to a temporary reduction in course offerings and a 12 percent decline in systemwide enrollments. Beginning in Fall 1994, however, enrollments have risen for three consecutive years, and the Governor's "Compact" with the public higher education systems to fund enrollment growth more adequately offers a degree of hope for the immediate future.

In *A Capacity for Growth* (CPEC 1995b), the Commission projected that State University enrollment demand would increase by about 26 percent between 1993 and 2005. Concomitant with burgeoning enrollments will be a relatively new and exceedingly complex set of challenges. For example, the Commission believes that the characteristics of the next generation of entering and continuing students are likely to be the most diverse in the history of the CSU with respect to academic and career interests, specialized training and work force needs, preferred learning styles, and demographic composition. The CSU leadership recognizes that the further deployment and application of information technology will provide one avenue of response to these changing environmental forces and to opportunities inherent in serving a growing and diverse population. In a recent status report on technology to the CSU Board of Trustees, Executive Vice Chancellor Broad reported that:

> The quality of learning can be enhanced through the use of information technologies that address individual learning styles and the needs of diverse groups by enabling each learner's ability to control and direct the learning experience, and by increasing social interaction through the use of virtual and asynchronous modes of communication. Further, telecommunications technologies can increase student access to faculty and information providers and resources by making them available independent of time and place, and by reducing or removing the geographic, economic, and social barriers to learning. Investments in an integrated telecommunications infrastructure will promote greater sharing of programs, resources, and services among the students, faculty, and staff of CSU campuses as well as increase opportunities for cooperation among educational segments in California (p. 8).

Planning for the use of technology

The State University's interest and involvement in information technology dates back at least to 1963, when it was one of the first higher education systems to be granted a license from the Federal Communications Commission to offer distributed learning opportunities through the newly created Instructional Television Fixed Service (ITFS). These early experiences have guided more recent efforts to strategically deploy technology and telecommunications advances as part of a systemwide strategy to address the dual challenge of accommodating larger numbers of students while containing costs and preserving quality.

Integrated Technology Strategies Initiative

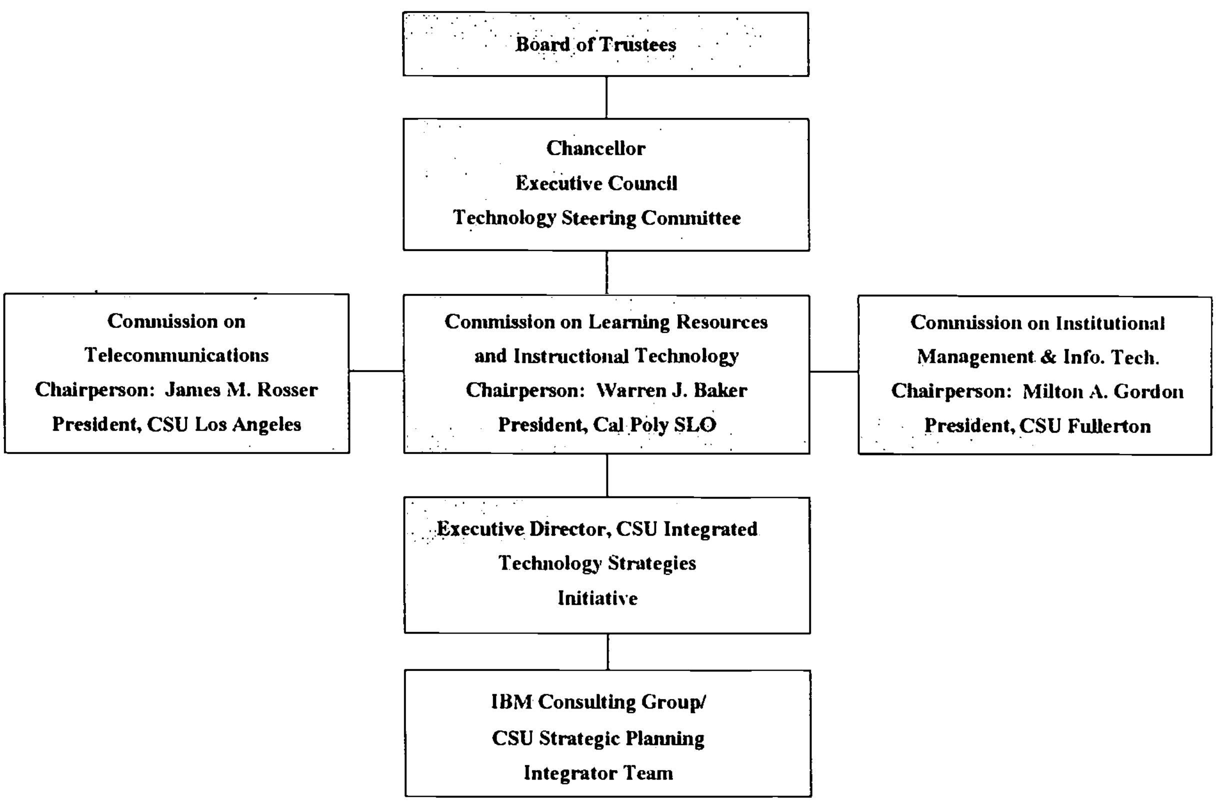
In response to the opportunities and challenges noted above, Chancellor Barry Munitz embarked on a comprehensive systemwide planning process to determine ". . . how best to leverage information technology to advance the mission and programs of the State University." The concerted planning effort is known as the *Integrated Technology Strategies Initiative* (ITSI) and involves: (1) three systemwide commissions (Learning Resources and Instructional Technology, Institutional Management and Information Technology, and Telecommunications and Infrastructure), chaired by campus presidents; (2) an Executive Technology Steering

Committee; (3) an IBM Higher Education Consulting Group; (4) an executive director for ITSI; (5) a Strategic Planning Integrator Team to advise the executive director and IBM team; and (6) partnerships with major stakeholders and national and regional constituency groups.

The *Commission on Learning Resources and Instructional Technology* was formed in 1991 to develop and recommend policy guidelines that would facilitate the effective uses of learning resources and instructional technology throughout the university in order to enhance teaching and learning. *The Commission on Institutional Management and Information Technology* considers ways to increase institutional productivity and accountability; the *Commission on Telecommunications and Infrastructure* is charged with overseeing the development of the physical infrastructure to support the academic and administrative applications of the other two commissions, and to ensure the efficient high-speed transmission of digital information based on upgraded hardware, software, and physical connections. The *Technology Steering Committee* coordinates the work of the three commissions. The overall governance structure for ITSI is presented in Display 1 below.

DISPLAY 1

Educational Technology Governance Structure
The California State University



The ITSI is centered around a set of core assumptions, as presented in Display 2, that reflects judgments about the effects of external forces on technology planning and implementation. As shown by Display 3, the Strategies Initiative also entails a set of principles that expresses the system's values and criteria for creating, selecting, and designing projects. The assumptions are grouped under six major categories -- academic, political, social, economic, organizational, and technical. Collectively, they highlight two key expectations that are particularly relevant to systemwide planning. First, although technological change is expected to enhance instruction and influence learning to be more independent, self-paced, and multimedia-oriented, public support of technology is not necessarily a given. Therefore, the CSU expects that it will face increased pressure to be accountable to the State and public for demonstrating increased productivity and improved effectiveness through the use of technology. Secondly, although the capabilities and costs of technology will continue to change at a rapid pace, in the long run, the CSU believes that it will cost the State more not to provide technology training to faculty, students, and staff than to provide such training.

As shown in Display 4, three initiatives form the foundation of the university's Integrated Strategy -- (1) Inter-Campus Networking Access, (2) Intra-Campus Telecommunications Infrastructure, and (3) Baseline User Hardware/Software Access, Training and Support. The first two are designed to provide CSU's 330,000 students, and 36,000 faculty and staff with the electronic mechanism and capacity to access information resources and to communicate with one another from any place at anytime. The major desired outcome is to facilitate individual and collective intellectual productivity. The third initiative provides the tools, training and support services necessary to effectively access and use information resources that will be available through the further development and enhancement of the CSU systemwide digital network.

Connectivity and infrastructure development

The CSU believes that the expedient implementation of the above interrelated initiatives is of critical importance to its future. At a meeting in October, 1996, Chancellor Barry Munitz and all 22 campus presidents agreed to form the Systemwide Internal Partnership (SIP) in order todevelop an implementation plan. Collectively, the three initiatives are referred to as the Technology Infrastructure Initiatives. The implementation plan will be based on extensive planning that has taken place over the past three years for each of the components that comprise this effort. The Inter-Campus Networking Access component is designed to permit communication from campus to campus; from campus to local communities; and from campus to information resources across the state, nation, and world that could also include system-to-system and intersegmental communications. It includes providing digital and analog facilities, satellite transmission and reception systems; connections to local distribution systems; and, linkages to worldwide networks such as the Internet. The outcome is to enhance, augment, and replace the existing inter-campus network as necessary to support the mission of the CSU and the California Community Colleges.

DISPLAY 2

The California State University Technology Planning Assumptions

Academic

- Technological change will influence all types and styles of learning to be more independent, self-paced, and multimedia oriented.
- Academic programs will be challenged to keep pace with changing student and employer needs.
- Faculty turnover will be significant in the next ten years.
- Faculty, staff, and students will use technology in most aspects of their lives, requiring support different from that available today.
- Teaching and learning will not have to occur together at the same time and in the same physical space.

Appropriately supported faculty creativity and productivity will be enhanced and student learning increased.

Political

- State funding will not match what the CSU perceives as its needs.
- The CSU must adapt and be flexible in a state and federal political environment undergoing significant and unpredictable change.
- The CSU will face increased pressure to be accountable to the public and government for demonstrating increased productivity and improved effectiveness.
- Actions of other segments of California public education will continue to affect CSU policies and programs.

Social

- The CSU will draw from an increasingly diverse student population.
- The CSU will strive to continue to honor the Master Plan, providing access to higher education for all qualified students in spite of the increasing constraints.
- Public support of the value of a CSU education is not a given.

Economic

- Economic growth in California will be modest over the next few years.
- The public expects the CSU to employ various means, including technology, to increase quality, expand access, and improve productivity.
- Higher education will encounter price resistance.
- The pool of potential students will continue to grow while competition for them will increase, particularly from nontraditional sources.

Organizational

- Technology (among other forces) will cause dramatic changes in the way the CSU is managed, organized, and delivers its programs.
- The CSU will experience significant cultural stress as it is being changed.
- The CSU will enter into various types of partnerships to meet its mission, goals, and objectives.
- Efficiency, effectiveness, and quality will become key drivers in organizational success.

Technical

- Technology available at the end of the planning horizon will be different from that at the beginning of the process.
- Distance and time will be less of a barrier to teaching, learning, and working.
- Suppliers of technology will continue to change with no single source emerging as the "vendor of choice."
- Faculty and students will demand and need support for a wide variety of technologies.
- In the long run, it will cost the CSU more not to train its faculty, students, and staff to achieve information technology literacy than it will to provide them with such training.
- The capabilities and costs of technology will continue to change at a rapid pace.

DISPLAY 3

The California State University Technology Planning Principles

Overarching Principles

- The highest and best use of information technology is its application to the provision of quality higher education with a focus on the student and the learning, teaching, and underlying research supporting that quality.
- CSU should enter into partnerships only where there are clear alignment of incentives and a commitment to maintain the partnership over time by all parties.
- Individual and organizational behaviors that advance CSU-wide and campus initiatives that further the *Integrated Technology Strategies Initiative* (ITSI) strategic plan should be rewarded.
- A balance between requisite technology infrastructure and baseline access for faculty, students, and staff and more advanced technology projects should be maintained.
- Faculty, students, and staff should have easy, well-supported electronic access to the data and information necessary to their university functions regardless of location.
- Information technology products, services, and projects should be measured and supported primarily for their benefit to CSU's strategic objectives.
- CSU should be known for using proven information technologies in "cutting edge" ways to further its mission.
- Applications of information technology should always provide both increased efficiency and effectiveness while maintaining or improving the quality of the function(s) they support.
- The information technology applications most valuable to the CSU are those which are planned and developed only and shared with and implemented on multiple campuses.
- Where the CSU has already achieved competitive advantage from its information technology accomplishments, the advantages should be leveraged to accelerate the implementation of the ITSI strategic plan.

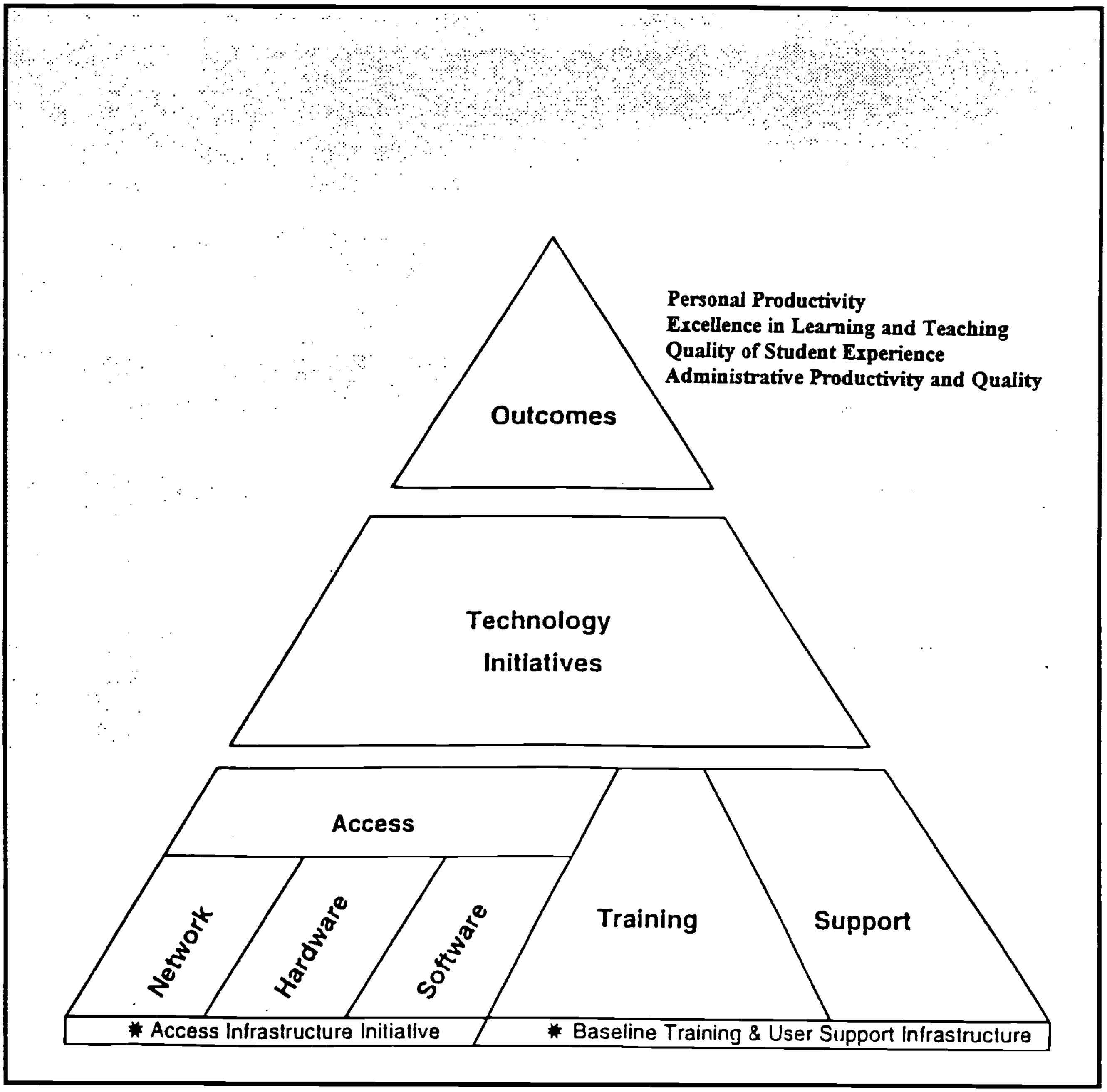
Priority Principles

- Priority should be given to projects with clearly defined benefits for the faculty/student learning environment.
- Preference should be given to initiatives that facilitate partnering among campuses for the design, implementation, and use of common applications.
- Preference should be given for those initiatives meeting common objectives, yet capitalizing on local autonomy and using local strengths.
- Preference will be given to projects that further faculty, student, and staff information technology literacy.
- Projects/initiatives that generate new resources either through revenue or by freeing up current resources will be preferred over those that do not do so.

Design Principles

- The quantity and detail of data collections should be no greater than that required to perform the functions for which they are collected.
- Data should be collected once, electronically, as close to their points of origin as possible.
- All ITSI initiatives (other than experimental projects) should provide at a minimum:
  - A plan for user support and training
  - A detailed benefits description
  - Measures for evaluation and performance
  - A description or organizational implications and a plan to deal with them.
  - A description of impact on roles and responsibilities.
  - As a rule, new applications should be easier to use than the manual or automated system(s) they replace as judged by their users.

DISPLAY 4: Integrated Technology Strategies Initiative Framework



The existing inter-campus networking infrastructure, CSUnet, has been a continuously evolving California educational network that meets the growing needs of the CSU. Many other universities, community colleges, public schools and libraries are also part of CSUnet. As such, much has been done to scope the future direction of networking technology consistent with current planning documents and industry standards. Implementation is already underway to create a shared network with the California Community Colleges by adding their 125 sites to CSUnet and renaming the network. From the CSU perspective, this collaboration is viewed as the first phase in developing a statewide educational network involving all systems. In fact, planning is already underway involving representatives for all three public systems as well as the independent sector. The CSU has projected that it will need to commit a minimum of 10.5 million per year for the inter-campus networking access to meet its own program needs. This does not include the costs for the community colleges.

The second component of the Technology Infrastructure Initiatives -- the Intra-Campus Telecommunications Infrastructure-- involves providing each CSU campus with a high quality telecommunications capability and capacity for the transport of digital and analog signals carrying voice, data and video services to assorted workstations located in classrooms, laboratories, and offices throughout the campus. The purpose of this initiative is to enable students, faculty, andstaff to have technological access to information resources and to engage in electronic communication relying on a robust and ubiquitous "baseline" intra-campus network infrastructure for internal and external telecommunications. The thrust of this initiative, summarized in Display 5, is to reinforce, renovate, add and replace the intra-campus media, pathways, space and terminal resources necessary to achieve a *baseline* capacity that will enhance the academic and institutional program goals and the mission of each campus and the CSU system. Over the past four to six years, the technological revolution has changed the nature and need for telecommunications in education. As part of the ITS, in-depth master planning was done at each CSU campus in FY 1995-96. That planning resulted in a projection that over $400 million would be needed for the intra-campus telecommunications infrastructure to meet the full program needs of the campuses. Of that total, a minimum of $200 million would be required to provide for the baseline needs. During the past six months, all campuses have developed preliminary design plans for their baseline infrastructure needs. The CSU is seeking $18.0 million in its General Fund for FY 1997-98 to facilitate the design and implement these preliminary plans in order to launch this component of ITS.

The CSU recognizes a third component that is an integral part of developing and implementing the baseline infrastructure capability on each campus. This component involves providing a comprehensive baseline capability to train all the students, faculty, and staff to become information competent and to provide them continuing professional and technical support services. It also involves providing the basic quantity and quality of hardware, software, and local area networking resources to enable these individuals to have the appropriate access to information resources which, in turn, will increase their personal productivity. Campuses have submitted comprehensive plans for this component of the ITS.

The CSU has projected that a minimum of $100 per student headcount enrollment will be needed to undergird this component of ITS and has already designated $13.5 million of its FY 1997-98 funding in the Governor's Compact to launch the first phase of implementation.

DISPLAY 5

Infrastructure Strategic Initiatives
The California State University

Goals	*Strategic Deliverables*
Internal Infrastructure Upgrade infrastructure on each CSU campus to achieve uniform connectivity.	1. Install adequate building pathways, terminal rooms, and physical cable and wire of various types (fiber optics, twisted pair copper) to support connectivity of all classrooms, laboratories, faculty and staff offices to voice and video data and information. Estimated costs is $400 million, excluding electronic costs. 2. Encourage each campus to provide a minimum of three classroom environments suitable for distributed (distance) learning applications, particularly interactive compressed video.
External Infrastructure Upgrade CSUNet in order to enhance resource sharing and collaboration among CSU campuses and other public and private entities.	1. Convert to cell relay technology that will permit more efficient and cost-effective use of bandwidth when transmitting information. 2. Install Asynchronous Transfer Mode (ATM) switches to achieve significant improvements in the performance and reliability of broadband networking.
Extend telecommunications support to K-14 institutions to foster administrative efficiencies, collaboration, and consumerism.	1. Connect K-14 institutions to CSUNet using frame relay technology. This would mean that a single, high-capacity circuit could support 20 to 40 K-14 sites. Once connected, academic transcripts could be sent electronically to the CSU, high school classrooms could be used in the evening for college instruction, and K-14 institutions would likely become consumers of CSU-produced multimedia courseware.
Increase access to learning opportunities through the use of digital satellite uplinks and downlinks.	1. Digitally upgrade CSU analog systems to conform to satellite technology. Enlarge uplink channel capacity at CSU Chico and Sacramento from present single path to eight or more simultaneous compressed signals residing on a single satellite transponder. 2. Purchase the rights to at least one full-time satellite transponder dedicated to CSU campuses interested in pursuing a statewide instructional objective.
Increase access to learning opportunities through campus connections to Cable TV.	1. Ensure that all CSU campuses are connected to local cable franchises in order to deliver instructional programming into subscriber homes.
Form strategic alliances and partnerships with telecommunications providers in order to maintain the most optimal and up-to-date infrastructure.	1. Specific partnerships of interest include collaborative arrangements with the state's public education systems, the Bay Area Regional Research Network (BARRNET), the Pacific Internet Consortium, Pacific Bell, and General Telephone.

Teaching and learning initiatives

A number of proposed projects are intended to have direct consequences for improving the effectiveness of teaching and learning in the State University. *The Integrated Technology Strategies Initiative* focuses on four priority areas: (1) faculty training and development; (2) library development and access; (3) collaborative learning and teaching; and, (4) multimedia repository.

Faculty Training and Development: In July of 1995, a systemwide work group provided the Commission on Learning Resources and Technology with a report that contained specific recommendations and guidelines for promoting faculty development. The recommendations are based on (1) the application of information technology in the learning and teaching process; (2) a learner-centered pedagogy; and (3) a solid foundation for accountability. The work group emphasized that their task was not about technology per se, but rather about ways that technology could help instructors manage diverse learning styles within a single course or classroom, promote collaborative activities and interaction without the constraints of time or place, and help shift the role of the instructor from a conveyer of knowledge to a facilitator of learning. A recent systemwide survey of CSU faculty revealed that many faculty members have a high interest in technology, and that they would prefer campus-based training as opposed to regional programs. Accordingly, the workgroup recommended a team approach to development. The proposal builds on existing campus-based efforts and encourages the creation of faculty training teams that would take advantage of systemwide or regional workshops and then return to their respective campuses to provide training to their peers. This approach is intended to assure that successful training efforts will be disseminated throughout the system.

As shown by Display 6 below, the primary goals of faculty development include enabling faculty members to select and adapt appropriate tools to support their own teaching and learning objectives. The implementation model calls for the creation of a central pool of faculty development experts and resources; the development of a Request for Proposals (RFP) process that would solicit proposals for systemwide development institutes; and a RFP process for funding individual campus implementation initiatives. The combined efforts are expected to cost just over a half million dollars during the 1996-97 academic year. The systemwide training awards are expected to average $50,000, with each faculty trainer receiving a $500 stipend. Campus-based awards are projected to average $20,000. Since it is almost certain that there will not be sufficient funding available to the Commission on Learning Resource and Technology to fully support all components of faculty development, campuses will be encouraged and expected to offer matching funds.

Greater reliance on digital information, telecommunications, and electronic media systems are expected to be key components for transforming our nation's libraries.

Library Development and Access: It is recognized that the knowledge society of the 21st century will necessitate an expansion of traditional library services to permit multiple ways of searching, accessing, and retrieving information that is independent of time and physical location and customized to meet an array of user needs. Greater reliance on digital information, telecommunications, and electronic

DISPLAY 6

Faculty Development and Training Goals

- Facilitate an examination and implementation of new teaching/learning paradigms that make the best use of available technologies;
- Develop campus-based faculty training teams and programs for using new media and other technological tools as a means of enhancing the teaching and learning environment;
- Capitalize on existing investments of time and resources in CSU campus-based faculty development programs by encouraging dissemination of best practices and proven models developed in the context of such programs.
- Maximize the value of external resources accessible through the Internet by enabling faculty to enhance the learning and teaching environment;
- Enable faculty to select appropriate tools to support their own teaching and learning objectives;
- Foster development of models for effective use of technology for student-centered learning;
- Develop new opportunities for collaboration between campuses, including refinement of existing campus-based faculty development models through input from other campuses;
- Assess models of faculty development (formatively as part of the RFP process and through ongoing multi-campus program review and summatively through a study of program outcomes); and
- Evaluate new technology applications to the curriculum and their replicability to other CSU environments.

media systems are expected to be key components for transforming our nation's libraries. Moreover, the National Information Infrastructure proposed by the Clinton-Gore Administration is intended to ensure equity of access to information resources across all socioeconomic strata.

The CSU reports that all 22 of its campuses presently have online catalog systems and most offer a wide range of advanced technological services, including electronic access to indexed periodical literature using CD-ROM, searching capability through the use of networks, and linkages to national and international databases. In 1994, the Council of Library Directors (COLD) provided the Commission on Learning Resources and Technology with a strategic vision and plan that would establish CSU library facilities in the 21st century as intelligent structures that take advantage of emerging technologies to greatly improve the delivery of recorded knowledge and information. The Council recommended 31 priority goals and strategies in the areas of information resources, instruction, human resources, infrastructure, administration, and funding. The plan preserves the historically intrinsic characteristics of CSU libraries (e.g., interpersonal research relationships and access to archival materials and print collections), while providing an electronic environment for teaching, learning, and accessing information wherever it is located or needed.

The plan also accentuates the need for the State University to provide instruction and assistance in the use of recorded knowledge and information, and to join national efforts to develop new copyright guidelines appropriate for a National Information Infrastructure. In December of 1995, the Commission on Learning Resources endorsed a set of guidelines that would establish basic information competencies that students would need to demonstrate upon entering and graduating from the university. A review of the literature on information competency programs, undertaken by a faculty workgroup, indicated that the best programs are those that are integrated into the curriculum and that build on strong alliances between discipline and library faculty members. Display 7 below lists 11 basic competencies for evaluating the ability of students to find, evaluate, and use recorded information and data.

DISPLAY 7

Proposed Information Competencies

In order to be able to find, evaluate, use, and communicate information, students must be able to demonstrate these skills in an integrated process:

1. State a research question, problem, or issue;
2. Determine the information requirements for the research question, problem, or issue;
3. Locate and retrieve relevant information;
4. Organize information;
5. Analyze and evaluate information;
6. Synthesize information;
7. Communicate using a variety of information technologies;
8. Use the technological tools for accessing information;
9. Understand the ethical, legal, and socio-political issues surrounding information and information technology;
10. Use, evaluate, and treat critically information received from the mass media; and
11. Appreciate that the skill gained in information competence enable lifelong learning.

<u>Collaboration and Multimedia Repository</u>: In 1992, the CSU initiated Project DELTA (Direct Enhancement of Learning Through Technological Assistance and Alternatives) to investigate the potential use of technologies to enhance the teaching and learning process, and to facilitate intercampus sharing of program offerings, resources, and services. Initially, three projects were funded: (1) a joint MBA

Program that involved the Chico, Hayward, Sacramento, and San Jose campuses; (2) a Collaborative Multimedia Program to establish a database of digital images and audio to support computer-augmented lectures and virtual laboratories; and (3) a Multimedia Distance Learning Program to pilot-test the delivery of general education courses to pre-college students attending high schools in rural communities. As of 1996, a total of nine projects were funded. The university recently completed a summative evaluation of Project Delta, and a report of major findings is forthcoming. Present efforts to promote collaboration are focused on the further development of e-mail systems, teleconferencing, electronic transfer of class materials, and a repository of instructional technology materials.

Administrative initiatives

In addition to improvements in teaching and learning, the continued development of the university's internal and external infrastructure is expected to enhance the quality and delivery of administrative and student service operations through improved efficiencies and productivity. The *Commission on Institutional Management and Information Technology*, chaired by President Milton Gordon of CSU Fullerton, is currently sponsoring several key administrative initiatives.

With respect to campus life, The *One Card Initiative* is intended to provide faculty, students, and staff (and eventually alumni) with a single plastic card that can be used for facility and service access, long distance telephone service, and debit card service. The *Student Friendly Services Initiative* is a collaborative effort among higher education groups to develop and implement an electronic student admissions application form. The initiative is intended to simplify the admissions process for prospective students through the use of a single admission form that can be accessed through personal computers.

Regarding productivity concerns, the *Administrative Systems Portfolio Migration Initiative* seeks to move the university from its current decentralized administrative systems environment to one that utilizes a small number of different systems that can be shared by many campuses. The CSU also intends to realize economies of scale by drastically reducing the number of campus data centers, and by developing systemwide buying cooperatives for hardware, software, and network resources. These efforts are being directed through the *Re-engineering Information Technology Delivery Initiative.* It will create two or three shared data centers that will be managed using a cooperative organizational model. Finally, the *Re-engineering Procurement Strategy* is focused on developing optimal models to improve the effectiveness of the procurement process and to lower costs.

Summary

The California State University considers the *Integrated Technology Strategies Initiative* (ITSI) to be a dynamic and comprehensive long-range planning framework in which to effectively improve educational quality and student access. In this regard, the projects and initiatives currently undertaken or planned that are noted above represent initial efforts that are expected to be enhanced, refined, and expanded over time. A key assumption underlying the framework is that the technologies available at the end of the planning horizon will be different from those at the beginning of the process, and that the capabilities and costs of technology will continue to change at a rapid pace.

Within this context of continuous change, the California Postsecondary Education Commission believes that a thorough discussion of the possibilities technology presents is imperative. This imperative should assure that continued attention is given to assessment and research activities that can document the impact of technology at the State University and inform the efforts of the remaining public systems of higher education, whose own efforts are not nearly as comprehensive or well developed as the State University.

5 University of California Technology Initiatives

Introduction

The University of California was founded in 1868 as a result of the Morrill Act -- the act establishing land-grant institutions of higher education -- which was signed into law on July 2, 1862 by President Abraham Lincoln. The University is this State's official land-grant university. It has been granted autonomy in the California Constitution and has sole authority among public institutions to provide instruction in doctoral and professional degree programs. California's Master Plan for Higher Education also includes basic research in the mission of the University, the only one of the public systems of higher education to be given that responsibility.

The University of California is governed through a gubernatorial appointed Board of Regents with the basic administrative affairs of the University managed by the systemwide Office of the President. Primary responsibility for academic affairs of the University has been delegated to the faculty.

It may be fairly stated that the University of California has been intimately involved with technology since its founding, at which time the University of California was charged to create:

> . . . at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic art . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life . . . (Hofstadter and Smith, p. 568).

That specific charge to teach science and the "mechanic arts," the latter term almost the 19th century equivalent of "technology," was truly a directive to explore the boundaries of knowledge in order to bring about an improvement in the quality of life. In agriculture, where intensive study was specifically directed by the Morrill Act, the results of innumerable applications of science and technology have produced the most productive industry of its kind in the world. And in a host of other areas that most people associate with technology today, including those of computers and telecommunications, engineering and physics, biology and medicine, the University has invariably been on the cutting edge, and has not only employed the technology of the day extensively, it has also been partially or wholly responsible for creating it.

The University's technological accomplishments, which have placed it among the premier research institutions in the world, are widely conceded by virtually everyone. However, the considerable contemporary pressures for efficiency, productivity, and accountability have led many to ask whether the University has been able to use technology to its best advantage as a way not only to improve the quality of instruction, but also to deliver it less expensively.

The Commission has reviewed a recent University overview of its current use of learning technologies as well as the impact technology has had on its operations in other respects (University of California, 1996b). As the University indicated in its report, the summary of activities is intended to be neither definitive nor inclusive, and indeed cannot be, since the field of learning technology is changing so rapidly that any attempt to provide a comprehensive inventory would be out of date before a full compilation of activities could be completed. Accordingly, the next few sections indicate the ways in which the University is planning for a technological future, expanding networking and telecommunications, offering courses and programs by distributed learning (also referred to as "distance learning"), and attempting to create improvements in quality, access, and productivity.

Planning for ubiquitous networks

For several decades, ever since the first higher education courses were transmitted to a location removed from a main campus, most people have associated educational technology with distance learning, defined as the remote transmission of a lecture. At the University of California, such transmissions have been occurring since the mid-1960s, but they have been limited in scope and often expensive to implement. In recent years, however, technology has permeated almost every activity in which the University is engaged, primarily in the form of personal computers, but increasingly in the form of networks of personal and larger computers that are now becoming almost ubiquitous in scope, and that are accessing databases of such grand extent as could not have been envisioned even a decade ago. The Internet alone, which derives at least part of its genesis from academe, is expanding at the rate of 6,000 new sites per day, and as the speed and capacity of transmission facilities expands (i.e. increasing bandwidth), it is possible to foresee a time when an individual, sitting at home, can have access to an array of knowledge sources that will seem to have no limits whatsoever.

This represents a challenge to the University of California, and indeed to all of higher education, that is formidable and possibly even intimidating in the sense that it brings on change so fast that there is little time to plan for or react to it. The University is making an effort to meet this challenge, however, in a number of ways. Perhaps first and most important, it is organizing an "All University Conference" to be held in March 1997 "on instructional technology and its uses and future with UC." The University has high hopes for this assembly, and notes:

> This conference will bring together faculty, students, administrators, and Regents across the University to increase understanding of how these new tech-

nologies can be most effectively deployed to help the University fulfill its mission . . . . The University envisions that the advances in learning technologies will require us to rethink every aspect of how we do business (UC, p. 19).

The University hopes that this conference, in conjunction with a number of systemwide planning activities, will produce not only a comprehensive assessment of technology's impact on University operations, but also provide a more definitive purpose for future technological applications.

Previously, the University noted that "no systematic assessment of capability and future needs had been made for some time," and accordingly created three successive task forces to consider various aspects of the technological challenge.

1. *The Task Force on Intercampus Programs and Distance Learning*

This task force was formed in 1993 to encourage intercampus program delivery through various distance learning technologies. The clear purpose, in effect, was to find a way to network the entire system so that students could take courses not only from their campus of residence, but from virtually any campus in the UC system. Among the technologies to be used were networks (including proprietary UC networks and the Internet) that could enable interactive computing, multi-site video and audio links, and online library catalogs and materials. In addition, this initiative involved video conferencing, electronic mail, shared computer data bases, and interactive multimedia technologies.

This task force filed its report on March 14, 1994. At present, the University's planning efforts in this area are continuing, with various work groups exploring ways in which intercampus connection and cooperation can be expanded. At present, the initiatives from this task force have produced several results, even though formal agreements among the campuses have yet to be finalized, and the University has not yet designed and built all of the networking and computer infrastructure that will be necessary for widespread intercampus efforts.

2. *The Task Force on Telecommunications Infrastructure Needs for Distance Learning*

This group began its activities immediately after the first task force filed its report. Its charge was to develop a five-year plan for upgrading the University's network to fulfill the goals established by the first task force. Specifically, three recommendations were offered:

- Develop a university-wide distance learning infrastructure to be phased in over the next five years; each campus is to have at least one fully equipped send/receive video and audio studio.
- Assemble a properly trained staff of technical personnel at each facility.

- Upgrade the University's Intercampus Telecommunications Network (ITN) to include at least one T1 (see Appendix B for a glossary of terms) connection dedicated to video teleconferencing.

The University reports that, following the filing of this task force's report on July 22, 1994, the Office of the President began implementation of the recommended upgrades and improvements. Thus far, about $3 million has been expended, which the University concedes is insufficient in comparison to overall needs.

3. *The Task Force on Wide Area Networking (WAN)*

This group was formed to continue the progress of the first two task forces, but with the specific charge to chart the University's long-term direction for networking. Without actually saying so directly, it reflects the reality of a future that most informed observers of educational technology take for granted -- ubiquitous networking will be central to everything higher education does with technology. Without it, computers cannot be linked, campuses cannot be linked, and each campus, faculty member, and student cannot be linked to a larger world where information is expanding exponentially.

The University, through this task force, recognizes this fact, as well as the fact that network infrastructure is expensive, and has accordingly given it three charges:

- to identify the most cost effective network technology that will support high bandwidth requirements for intercampus communication and Internet access;
- to create a funding model for networking infrastructure for the next generation of campus and intercampus telecommunications; and
- to explore ways to give every student, in all systems, access to the ubiquitous networking of the future, and at the same time to leverage collective buying power.

This task force is due to submit its report at about the same time this report is being written, so it is not possible to comment on it further. It seems probable, however, that the task force will propose significant expenditures for the University, and possibly offer recommendations for an expanded relationship with the other two public systems, and private and independent institutions as well.

Connectivity and infrastructure development

As noted above, the University has focused its planning efforts, to one degree or another, at the challenges of creating a comprehensive network infrastructure. As it notes in its report to the Commission:

> Demand for network capacity has been generated by increasing dependency on the Internet for access to information resources, distance learning, MELVYL access to bit mapped images, multimedia applications, research activities heavily dependent on communications, and distributed computing environments (p. 5).

In part, the demand stems from the introduction of video into the transmission equation; video requires much greater amounts of memory and transmission capacity (bandwidth). In addition, the University notes that there is a trend towards the transmission of full-text documents from libraries, and a much greater use of e-mail. All of this requires larger systems.

To meet the increased demand, networks are being extended to residence halls and to virtually every other kind of building on campuses. All UC campuses have achieved basic backbone connectivity to pertinent buildings, faculty offices, residence halls, and some classrooms. Overall, some 14 percent of the classrooms are wired; the Irvine campus has achieved 100 percent connectivity to classrooms. All campuses now have formal distance learning video-conferencing classrooms in place, and all are continuing to upgrade their networks. For example, UC Davis's *Network 21* project involves a $23 million expenditure to create a campus-wide fiber-optic backbone that will be enhanced further by the installation of ATM switching technology. A similar project is underway at UCLA that is known as the *Connectivity Project*. The University estimates that the total cost of completing campus technology infrastructure is $60 million.

In January 1996, the University upgraded the network which had provided intercampus connections -- one that supported MELVYL, video conferences, and administrative functions like payroll -- for the prior 10 years. Improvements are in place now at the Office of the President, The Berkeley campus, and will be extended to other campuses in 1997. Video conferences will be carried on the old system, with all other applications integrated into the new, faster system. The next phase calls for the University to operate a single, broadband system utilizing a faster Asynchronous Transfer Mode/Synchronous Operation Network (ATM/SONET) protocol.

Recently, the University decided to join 33 other research universities to create what is to be called "Internet II," a new network that will offer higher transmission speeds and more reliable service than the current Internet. According to the New York Times:

> . . . the new network is intended to deliver the vastly higher speeds needed to allow the simultaneous transmission of voice, video, and data. Internet II would give researchers the bandwidth they need to enable distance learning, digital libraries, and on-line collaborative research (1996).

Internet II will require that universities across the nation connect to regional or statewide networks that also use high bandwidths. UC is collaborating with the California State University, Stanford University, the University of Southern California, and other institutions to develop a California strategy for access to Internet II.

Ultimately, when and if telecommunications companies expand their own transmission capabilities, Internet II may be folded back into an expanded and strengthened general Internet, but for now, the universities believe that they may need their own system.

Teaching and learning initiatives

In the early 1970s, there were a number of experimental efforts to expand access in all three systems of California higher education through distance learning. At the University of California, these efforts led to some funding for the Extended University, which provided a few part-time degree programs at both the undergraduate and graduate levels. Some found these programs appealing, but the costs were high in comparison to more traditional degree programs, so funding was soon discontinued and the Extended University allowed to fade out of existence.

At least in part, the Extended University failed because:

- it was ahead of its time and lacked supporters in sufficient numbers;
- the requisite networks and telecommunications infrastructure were not in place;
- its scale was small;
- its funding was too limited;
- its use of television as the primary delivery medium was too one-dimensional to succeed; and
- its use of "bolt-on technology" to provide instruction in a highly traditional format was not considered pedagogically sound or effective.

Today, once students arrive on campus, they will find numerous changes in the way course materials are delivered from the experience of earlier generations at the same institutions. They will have e-mail access to their professors, about two-thirds of the students will own computers (increasingly, these are portable, notebook computers), all will have access to computer technology, and all will use the Internet and other computerized networks that will connect them to each other, to the larger university community, and to the world. However, these changes have not yet revolutionized the teaching process -- the didactic presentations of the lecture/laboratory mode, often given in large auditoriums, remain more or less unchanged from earlier eras -- but there should be little doubt that further changes are coming that will probably include the introduction of CD-ROM courseware and direct network instruction. These will occur more slowly and deliberately than in research and administrative functions, but they will surely come, and probably sooner than many expect.

That teaching will change more gradually than other university activities should not be entirely surprising.

That teaching will change more gradually than other university activities should not be entirely surprising. Efficiencies in administrative practices, so widely used in business and industry, have obvious counterparts in academe. And as noted above, research faculty have embraced technology because they have seen equally obvious ways that both the quantity and the quality of their research can be improved. In instruction, however, the benefits have not only been less obvious, there have been serious and important questions raised about whether technology will actually maintain existing levels of quality, let alone expand them. For that reason alone, because so much more needs to be known about the ways that students learn, faculty have been reluctant to replace traditional forms of instruction with technological substitutes.

There has also been an element of anxiety in this equation, a phenomenon anyone familiar with the sociological implications of technology should know well; the fear of being replaced by a machine. The most extreme example of this fear was probably the Luddites of the early 19th century, who destroyed textile mills in England out of the mistaken belief that machines would destroy their livelihoods. At other times, labor unions have expressed concerns about the potential of automation to replace workers. Today, there is no comparable sentiment on any campus to eliminate computers and networks, but there is a level of anxiety among many faculty that technology may be embraced for its own sake, rather than being carefully examined as a potential way to improve both access and quality.

Perhaps ironically, it may be the ready acceptance of technology by the research faculty of the University of California that leads to a reformation in teaching. Research units such as the Berkeley Multimedia Research Center and the UCLA Center for Digital Innovation may well demonstrate that multimedia and distributed learning should be broadly implemented in the instructional process. Should that occur, and it seems quite probable that it will, the University's instructional function may be the recipient of as many benefits as have accrued to research and administration -- topics discussed later in this chapter.

Increasingly, University of California faculty are becoming interested in multimedia course modules. Two centers, the Berkeley Multimedia Research Center (BMRC) and the UCLA Center for Digital Innovation (CDI) are exploring ways to provide instruction that will permit not only a more interesting presentation of data and concepts to students, but which may also permit those students to advance at their own pace and at their own convenience, not being bound to a particular time or place for a lecture or even a laboratory. There are numerous pedagogical, articulation, and even accreditation issues involved in these new ventures, as Chapter Two of this report has made plain, but it appears that progress is being made to make the delivery of curriculum not only more flexible, but quite possibly more effective as well. The University has noted that many of these modules are targeted to introductory courses, an area the Commission feels may bear considerable fruit. Such courseware may also be effective in alleviating certain academic deficiencies in reading and math among entering students.

The University is also involved in various national coalitions to develop multimedia courseware, particularly in science and engineering. These involve faculty collaborations among several UC and CSU campuses, nine community colleges, and three historically Black colleges in Atlanta. The ultimate objective is major curricular reform in the sciences using interactive multimedia modules that can:

> . . . combine simulations and exercises in core engineering knowledge with case studies that demonstrate the interaction between scientific research and organizational decision making to achieve actual engineering breakthroughs. Students use the modules in independent study under supervision of and in consultation with faculty and teaching assistants in a variety of institutions (p. 9).

In its report to the Commission, the University detailed a long list of programs and intersegmental cooperative efforts that employ technology. Among them are cross-campus collaborations to offer courses in rarefied fields with low enrollments such as certain language programs (e.g. Armenian), or highly specialized science and engineering curricula. Other cooperative programs currently in existence include graduate pharmacology and nematology. There are also intersegmental programs in various fields involving both the State University and the community colleges, all using interactive teleconferencing facilities.

As interesting as many of these efforts are, it is likely that the greatest instructional innovations have been occurring not in the regular credit programs of the nine campuses, but in University Extension, which is the University's largest division. As of 1994-95, University Extension offered nearly 18,000 courses to 419,186 students in a host of fields. Of these, some 59.3 percent were in professional courses and programs, 33.7 percent in non-credit programs, and 7.9 percent in courses transferable to regular campus degree programs. Perhaps because of its largely non-credit format, University Extension may find it easier to experiment with new delivery modes, but irrespective of the reason, it is clear that new delivery systems are being used, including various forms of remote delivery, the use of e-mail and fax to submit assignments, and even the direct delivery of courses through on-line services like America Online.

A few specific examples may help explain the kinds of programs and services University Extension is providing:

Berkeley

- In collaboration with CMIL (Center for Media and Independent Learning), UC Berkeley will put 175 courses on line over the next three years, with the help of a $2 million grant from the Sloan Foundation.
- The Extension Education Network -- ExtEn -- now links sites in Berkeley, San Francisco, San Ramon, and Menlo Park through two-way interactive video conferences.

Davis

- A course in fire prevention is offered via microwave link to Lawrence Livermore Lab, and a Fundamentals of Chemistry course is also telecast from UC Davis to Livermore.

- UC Davis is currently developing a CD-ROM course in Visual Basic Training for broad distribution; and consultation/teaching via CU-See Me technology for child welfare agencies throughout California.

Los Angeles

- For several decades, UCLA Extension has taught classes over compressed video for contract training to multiple sites; used videotapes; and has provided content for the Hospital Satellite Network.
- UCLA Extension recently signed an agreement with The Home Education Network (THEN) for dissemination of curricula and curricula-designed capacities through all known technologies. A similar Writer's Program began offering online instruction in 1995.

Riverside

- Classes in Environmental Science are planned with interactive video and audio seminars between UC Riverside and other UC campuses, including a certificate program in Air Quality Management.
- Online extension classes in Environmental Science are offered via the Internet.

San Diego

- In collaboration with "Access Excellence," a national educational program sponsored by Genentech, UC San Diego is offering an online courses in *The Scientific Basis of Nutrition or Are We Really What We Eat?* The course puts high school biology teachers in touch with their colleagues, scientists, and sources of new scientific information through an online network.
- UC San Diego Extension is planning to offer online courses and certificates in information technology and multimedia programs.

It is clear that much is happening in both regular and extension programs to explore new ways to deliver instruction. Many of these efforts are in the experimental stage, and may or may not prove useful in the future. It is also clear that, while some planning is underway, much more is needed and, with the University-wide conference scheduled for the spring, will almost certainly be forthcoming. All that seems certain is that everyone is convinced that ubiquitous networks will be present in any future for higher education that can be conceived of today.

Research applications

The final section of the University's report to the Commission is entitled "Initiatives to Enhance Quality, Improve Access, and Increase Productivity." It contains three sections that discuss the uses of technology in academic areas, libraries, and support services.

In the section on academic uses, most of the discussion centers on the University's research mission. In an important sense, this is appropriate, since the University has used state-of-the-art technology in the furtherance of its research mission ever since its founding in 1868. In recent decades, as the pace of technological advancement has reached dizzying speeds, the University's researchers have embraced technology with great enthusiasm. Particularly in the sciences, but no less so in the social sciences and humanities, University faculty saw the computer as a tool that could produce knowledge and invention undreamed of only a few years before.

The invention of micro-circuitry permitted scientific measurements that were more precise by several orders of magnitude and that created entirely new subdisciplines in the process. Researchers in fields that involved the analysis of massive data arrays, such as weather forecasting, saw immediately that the digital revolution would revolutionize almost everything they had ever done. The creation of the UC San Diego supercomputer center, funded by the National Science Foundation, is an example of both the faculty's realization of technology's potential, and its dedication to pursue that potential aggressively.

Administrative and student services

Technology has been quickly embraced in other areas of the University's life as well, particularly libraries, and increasingly in academic and student support services as well.

The revolution in the library is particularly interesting. Computers and networks are most useful in organizing and transmitting large amounts of information, and in no field of endeavor is organization more compellingly required than in a library. As the University appropriately notes in its report, "The University of California was an early and enthusiastic adopter of information technologies for application to library and information services" (p. 16). In 1977, a major study of library operations led to recommendations to computerize the entire card catalog as well as to automate circulation operations. The result, as the university reported, is:

> . . . an electronic library information system that has since evolved far in excess of the expectations of its original planners. The University-developed union catalogue, the MELVYL system, is a computer-based library system . . . that allows users to search a variety of bibliographic databases and to connect to other databases and systems at UC campuses and elsewhere . . . . Currently, there are 8.1 million unique titles, representing 12.4 million holdings available via MELVYL. The periodical database includes over 790,000 unique titles of newspapers, journals, proceedings, and maintains over 1,000 journals online (p. 17).

This is an impressive indication of both a quality and productivity improvement. Ultimately, the University believes it will create a "Cyberlibrary . . . a virtual library that would be available to anyone with access to the Internet." Presumably, such a library could permit anyone with a computer, an Internetlink, and probably a credit or debit card, to access and download almost anything from almost anywhere, including highly sophisticated graphics such as classic works of art. As the University notes, it already has about 1,000 journals and periodicals on line, and it is probably not too far in the future when virtually all journals will exist almost entirely in cyberspace. Even outside of the academic community, most newspapers, including the New York Times, USA Today, the Wall Street Journal, and a host of others, are available today in digital editions on the Internet.

In academic and student support services, technology has also wrought great change. As examples, the administration of all student aid programs at the University is now performed entirely through the Internet. As the University noted in its report:

> The UC Office of the President maintains a Web server with various information links, providing access to campus Web sites. The central server also includes all university-wide policies and guidelines, such as the Bylaws and Standing Orders of the Regents, the Academic Senate Manual, Business and Finance Bulletins, the Accounting Manual, etc. General Information about the University of California and about its campuses can also be found on the Web, including General Catalogues, campus calendars, information about student housing, campus events, etc. The campuses and the Office of the President all maintain Web Home pages which lead the reader to comprehensive information about the campus or the University as a whole (p. 18).

Students now register and enroll in courses with their computers, and receive further information about course schedules, course availability, and waiting lists. Even counseling is available online, with students able to ask questions of a counselor, and receive an online or e-mail answer. The next stage -- the University's Pathways Project -- will be a complete electronic guidance, admission, and student data system that will "collect stored information about a student, including grades, SAT scores, and other relevant data, and use this information for application to the University" (p. 19). It will also provide notification of admission, financial aid, and pre-registration.

Summary

It is rapidly becoming axiomatic among those who study technology's effects on society that the very existence of computers, networks, compact disks, scanners, cell phones, modems, and a growing galaxy of software will create change even if there is no organized planning to implement it. The issue, therefore, is not whether change will occur -- it most certainly will -- but ways by which to develop strategies not only to maintain or enhance the quality of higher education, but also to deliver it more efficiently.

Given the pressing enrollment demands that are soon to wash up on higher education's shores ("Tidal Wave II") and the equally pressing demands on limited State resources, there should be little doubt that the University of California is facing a considerable challenge. To be sure, the University is keenly aware of the problem and committed to comprehensive planning for a future that is difficult to forecast. That planning agenda will be advanced on several fronts over the next few years, in part through the All-University Conference to be held in the spring of 1997, in part through the Commission's advisory committee that will also be formed in the spring, and in part through the numerous activities taking place on each campus.

Planning is occurring in other forums as well, of course, including at the Governor's Council on Information Technology. The Council's most recent report, published in the summer of 1995, contains an ambitious agenda for the implementation of various instructional strategies, including a technology-driven, student-centered learning environment and the convening of a "summit" to plan ways to:

> . . . achieve efficiency gains, reduce course overlap, enhance value to students, promote distance learning opportunities for students across systems, and consolidate "regular" and "extension" curricula -- and determine how information technology can help . . .

all within 120 days. To this, the University responded that while it generally supports the Council's views:

> . . . we seriously doubt that sweeping changes of the scope and magnitude called for in the Governor's Council report and anticipated in UC's vision for learning technology can be accomplished in the one- to six-month time frame suggested by the Council; this is the work of many years (UC, 1996, p. 4).

The Commission agrees with this assessment, not because it believes that the need for change is not pressing, but because the need for careful planning for that change is even more pressing. The greatest need at the moment, in the Commission's view, is to craft an agenda for change -- a possible shape of that agenda is discussed in the initial chapter of this report -- in order to define the most pressing issues that policy makers will have to consider in the next year or two.

6 Technology in Student Learning and Cognition

IN ITS LONG-RANGE planning document, *The Challenge of The Century*, the Commission highlights the dual challenge of accommodating large numbers of additional students seeking access to public colleges and universities and identifying strategies to achieve improved student outcomes. The incorporation of technology has been mentioned prominently as a part of any solution to the dual challenge of growing numbers and need for improved outcomes, although it is not the sole answer.

Earlier chapters of this report have provided brief overviews of the many ways that public colleges and universities are using technology to extend educational opportunities to Californians in remote locations through distance education; to improve communication and resource sharing between and among campuses through networking and infrastructure investment; to produce administrative efficiencies through more rapid exchange of electronic information; to enhance instruction; and to creatively think of new ways to control costs of technology through collaboration and partnerships with both public and private entities. California's public colleges and universities have progressed at different rates and in different directions consistent with the differences in their respective missions, clientele, and available resources.

Under the right circumstances and conditions, the Commission believes that educational technologies offer extensive opportunities for improving the quality of teaching and learning.

Under the right circumstances and conditions, the Commission believes that educational technologies offer extensive opportunities for improving the quality of teaching and learning and here it extends the discussion begun in the Commission's report *Moving Forward*. Its central purpose is to encourage the technology planning efforts of the systems to incorporate strategies for enhancing both teaching **and** learning. It seeks to do this by discussing in greater detail the importance and potential benefits of closely aligning current and future technologies with the specific cognitive processes, skills, and abilities required of diverse learners for effective problem solving, success in postsecondary education, and lifelong learning. Further, this discussion takes into consideration the diversity in learning styles and experiences of California's college students today and the role that technology can play in accommodating instruction to that diversity.

In reviewing the technology initiatives of the California Community Colleges, the California State University, and the University of California, it is evident that enhanced teaching and learning are two highly anticipated outcomes of technology planning. To this end, the systems have undertaken pilot projects to assess the effects of educational technology under various experimental conditions. Most recently, the State University, through Project DELTA (Direct Enhancement of Learning Through Technological Assistance and Alternatives), has provided approximately $4 million since 1993 to fund nine projects related to distance learning, telecommunications, electronic courseware development, library development, and technology-assisted teaching and learning. The Office of the President of the University of California has committed $250,000 for the 1996-97 academic year for similar projects, and the Board of Governors of the California Community Colleges has established a trial period through the year 2000 for districts to explore and develop distance education initiatives using advanced telecommunications.

Collectively, the pilot projects and research efforts of the systems can be grouped under two broad categories: (1) those that are intended to influence student outcomes indirectly through the use of technologies that permit increased access to information and knowledge; and (2) those projects and initiatives that are expected to have direct consequences for learning through the involvement of technology and instructional designs that have an impact on human abilities and skills.

The following discussion of cognition and knowledge construction is intended to provide a meaningful context for understanding the ways in which the use of technology can support improved teaching and learning outcomes.

The meaning of cognition and knowledge construction

In *Moving Forward*, it was noted that a growing number of educators now recognize that knowledge is not necessarily acquired simply by delivering declarative or factual information through lecture-based instruction. Rather, it is constructed by the learner through a complex sequence of mental and behavioral processes directed towards deriving meaning, interpreting, problem solving, and synthesizing information. While knowledge can and does exist independent of one's experience, it usually cannot enter the learner's awareness until it is purposely and meaningfully constructed or reconstructed.

Mental processes include abstracting and encoding crucial components of a problem situation, constructing a mental image of the problem in short-term memory that represents the appropriate relationships among the problem's components, making necessary inferences that assist the learner in thinking about the problem in a broader context, and selecting effective problem-solving strategies. Associated behavioral actions may include consulting with professors during faculty office hours, establishing support groups, participating in campus-sponsored discussions and symposiums, and discovering practical applications of subject knowledge.

Cognitive ability refers to the relative success of a learner in performing mental operations in various domains or subject areas. For example, in music and mathematics, the cognitive operations include encoding and mentally representing information through the use of symbols and notations that conform to logic systems.

Indirect use of technology to increase access to information and knowledge

Multimedia technologies, such as interactive Websites and Pages over the Internet, online electronic bulletin board systems, e-mail platforms, computer-mediated conferences, and digital library services, are considered by many educators to be worthy of State investment because they have been shown to (1) enhance the educational experiences of learners through expanded access to information; (2) provide more immediate feedback on course content; and (3) increase opportunities for student-teacher collaboration, exploration, and engagement. Educational planners and evaluators emphasize that it is not necessary to demonstrate that these dimensions or contributions of technology lead necessarily to improvements in learning outcomes -- although they often do -- in order to establish and validate their educational worth or value. Rather, it is sufficient, they argue, to show that such online arrangements and platforms maximize student choice by creating and supporting opportunities for learning that are independent of time and physical location.

Expanded access to information also supports equity in learning by making knowledge resources more accessible to part-time students, physically challenged persons, and working adults who have had limited access to, or ability to take advantage of, traditional educational institutions.

Numerous studies have corroborated the effectiveness of online-learning technologies to support learning activities (e.g., Bruce. Peyton, & Batson, 1993; Burge & Collins, 1995; Harasim, 1989; and Waggoner, 1992). For example, there is general agreement that the advent of the Internet, and especially the World Wide Web, is transforming the ways in which learners can access and disseminate information. More recently, Websites are being used by colleges and universities throughout California and the nation to support teaching and learning by linking course objectives to multimedia information and knowledge in academic, professional, and vocational content areas. E-mail systems and online bulletin boards enable learners to actively engage in discussions and workgroups from multiple locations that are virtually free of time constraints. Expanded access to information also supports equity in learning by making knowledge resources more accessible to part-time students, physically challenged persons, and working adults who have had limited access to, or ability to take advantage of, traditional educational institutions. Alternative learning opportunities have also been expanded in such a way that they compensate for libraries and computer laboratories that may have been outdated, overcrowded, and/or available only during selected hours.

Anecdotal information exists confirming that many students believe technology helps enrich their learning experiences. For example, Kearsley, Lynch, and Wizer conducted an attitudinal survey of 117 students enrolled in an online Masters' degree program in education in order to investigate the perceived benefits of an online Bulletin Board System (BBS). As part of their degree program, students paid a fixed fee for unlimited use of a BBS account that could be accessed either by a toll-free 800 number or through the Internet. The system provided sufficient memory, disk space, and telephone lines to handle the intense usage and interactions among students, faculty members, visiting scholars, and graduate assistants. A summary of the major findings from that survey revealed that:

- Over 97 percent of the students agreed that the BBS enhanced the television presentations and gave them an opportunity to communicate with other students;
- About 82 percent of the students believed that the BBS helped students assume the role of teacher themselves;
- Over 73 percent of the students agreed that BBS improved interaction among students and that the system provided an authentic learning environment; and
- Approximately 54 percent found the BBS to be helpful in improving writing skills.

Clearly, this study and others described in the literature demonstrates the power of technology to support teaching and learning indirectly through increased access to information and improved collaborative arrangements. However, less is known about the effective uses of technology to *directly* impact cognitive skills and abilities -- the subject of the next section of this chapter.

Direct use of technology to improve teaching and learning

Although many of the pilot projects supported by the systems are intended to improve learning outcomes, it is not entirely clear if enhancement of specific cognitive processes and abilities are the current driving forces impelling greater use of technology by educational institutions. Insufficient attention directed towards the enhancement of learning can result in costly, well-intentioned strategies for use of technology that are less effective than desired. Therefore, when the primary goal of a particular initiative or strategy is improvement in learning, it is crucial that the systems engage in appropriate research and assessment in order to demonstrate the ways in which the involvement of technology in instruction actually contributes to achievement of the desired change in learning outcomes.

The literature suggests that learning might be enhanced through technologies that accommodate or compensate for diverse cognitive styles, skills, and abilities, or that assist students in the development of more advanced skills and abilities, or a combination of both.

The literature suggests that learning might be enhanced through technologies that accommodate or compensate for diverse cognitive styles, skills, and abilities, or that assist students in the development of more advanced skills and abilities, or a combination of both. Display 8 below lists some of the metaphors that have been presented to describe ways in which computers can enhance teaching and learning.

Since learning outcomes are usually associated with a particular discipline that requires a range of skills and abilities, a thorough discussion of benefits from technology in instruction needs to focus on: (1) describing and operationalizing the class of human abilities or prerequisites assumed to be required for successful attainment of a particular learning outcome; (2) explaining in some detail the extent to which the involvement of alternative forms of technology in instruction might be effective in sharpening or accommodating varying levels of abilities and skills so that mastery and transfer of knowledge are likely; (3) specifying the underlying cognitive model(s) or theoretical hypotheses that best explain expected changes in learning performance, given a particular instructional strategy; and (4) validating expected changes in learning performance through empirical investigation. Under-

Display 8

Metaphors and Views Concerning the Role of Computers in Teaching and Learning

Computer Uses

* systems for automating education (Anderson, Boyle, Corbett, & Lewis, 1990)
* idea amplifiers; personal electronic teachers (Brown, 1984)
* cultural amplifiers; part of cultural tool kit; prosthetic devices (Bruner, 1986)
* reorganizers of mental functions; extra cortical organizers of thought; a medium that helps transcend the limitations of the mind (Pea, 1985, 1987)
* instruments of cultural redefinition (Bruner, 1986; Pea, 1987)
* intelligent tutoring systems (Anderson, Boyle, Farrell, & Reisser, 1984; Ohlsson, 1986; Sleeman & Brown, 1982)
* intelligent learning environments (Brown, 1984)
* idea amplifiers; facilitators of learning (Brown, 1984)
* amplifiers of the mind (Bruner, 1986; Pea, 1987)
* mirrors of the mind (Brown, 1984)
* an electronic workbook; a tool for learning through reflection (Collins & Brown, 1988)
* a medium for experiential learning (Lepper & Gurtner, 1989; Papert, 1980)
* a foundation for new learning cultures (diSessa, 1989)
* cognitive tools (Lajoie & Derry, 1993; Pea, 1987)
* partners in cognition (Salomon, Perkins, & Globerson, 1991)

standing such relationships and using that knowledge in planning for the involvement of technology in instruction may ensure that pedagogical strategies are appropriately tailored to match the strengths and weaknesses of individual learners.

Illustrations of the effectiveness of technology on learning outcomes

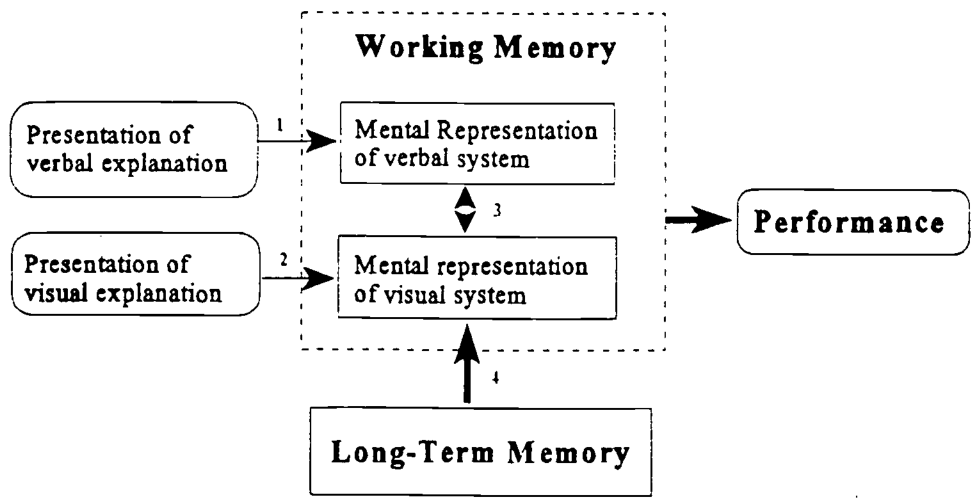
To help illustrate the effectiveness of technology when planning is informed by research findings, three examples are presented below. The first two are based on empirical studies, while the third represents a theoretical framework for planning. Example 1 highlights the ways in which a multimedia presentation of information can enhance the acquisition of scientific explanations of a system; Example 2 describes the use of computer-based games as a tutorial aid for improving the deductive reasoning ability of undergraduates; and, Example 3 discusses the potential effectiveness of technology in improving language ability when planning is closely aligned with cognitive theory and research.

Example 1: Enhancing the Acquisition of Scientific Principles through Animations

Between 1987 and 1994, Richard Mayer, professor of psychology at the University of California, Santa Barbara, conducted six major experiments to test the hypothesis that multimedia instruction -- in which words, pictures, and animations are presented contiguously -- would be more effective in assisting students to understand scientific explanations of a system than an instructional sequence where verbal and visual information were presented separately. In Professor Mayer's studies, the principal assumption is that the two separate coding mechanisms -- a verbal system for dealing with linguistic information and a nonverbal or imagery system for processing nonverbal objects and scenes -- are additive, so that information coded in both picture and verbal forms are more likely to be remembered. Display 9 below provides a graphical summary of this "dual-coding" theory adopted and modified for multimedia learning.

Display 9

Dual-Coding Process in Multimedia Instruction



Note: 1 refers to building verbal representational connections
2 refers to building visual representational connections
3 refers to building referential connections
4 refers to retrieval from long-term memory

With respect to these experiments, the effectiveness of multimedia instruction was measured by its ability to help students encode verbal and visual information, organize information in memory in the form of relational propositions, construct appropriate referential connections, and solve complex problems. Such problems required students to "troubleshoot" a system, predict outcomes if the system was modified, suggest system changes to accomplish goals, and develop hypotheses to explain the occurrence of certain events within a system. The emphasis was on the higher order mental faculties of analysis and synthesis, not just rote memorization.

Generalization from these results suggest that multimedia instruction would be especially effective in introductory college courses where the learner has not yet acquired a high level of subject matter knowledge (e.g.; introduction to biology, engineering, or economics, or remedial instruction in math and English).

The research findings and conclusions provided by Mayer have significant implications for instructional design and software development. First, the simultaneous (contiguity effect) presentation of verbal and visual descriptions of a system was shown across several studies to be as much as 50 percent more effective in promoting student problem-solving ability than instruction in which verbal and visual information was presented separately. Second, multimedia learning of scientific explanations was shown to be more effective for students who had low subject-matter experience but high spatial ability. Generalization from these results suggest that multimedia instruction would be especially effective in introductory college courses where the learner has not yet acquired a high level of subject matter knowledge (e.g.; introduction to biology, engineering, or economics, or remedial instruction in math and English).

Example 2: Improving Deductive Reasoning Ability Using a Computer Game as a Tutorial Aid

One of the distinct advantages of computer-based instruction is that once a content or learning module is developed, it can easily be tailored or adapted to fit a range of cognitive learning styles or individual needs. Computer tutorials are regarded as a useful adjunct to traditional classroom-based instruction because they provide immediate and consistent feedback while enabling the student to have complete control over the learning experience and to work through problems at his/her own pace. The use of computer games as tutorial aids is increasing in popularity because it has been found that students can "...lose motivation for continued drill and practice even when administered by a computer, unless it is done in an interesting context such as a game or simulation" (Wood & Stewart, 1987, pp. 53).

Mastermind is one such game based on logic and deduction. In its popular computer form, a secret code is randomly generated that consists of colored pegs arrayed over four to six positions. When four pegs are used with six colors, 1,296 unique combinations of colors in various positions exist. The object of the game is for the learner to break the code in the fewest number of trials. On each trial, the learner chooses some combination of colors and positions for the pegs, and the computer provides feedback regarding the correctness of choices. One type of feedback indicates correct colors that are in the wrong position, while the other response indicates that the correct color in a correct position. The student is required to deduce to which pegs the feedback corresponds. In a 1987 study, Wood and Stewart investigated the use of *Mastermind* to improve deductive reasoning ability. A total of 30 undergraduates enrolled in an introductory psychology course were randomly assigned to either an experimental or control group. Improvement in reasoning ability was measured by a modified version of the *Watson-Glaser Critical Thinking Appraisal* that required students to provide justifications for their responses to the test items.

Both groups took a pre-test but the experimental group interacted with the computer game for approximately a week before taking a post-test. The results revealed no statistically significant difference in mean scores for the control group, while the experimental group experienced a 41 percent reduction in the mean number of logic errors after exposure to *Mastermind*. The experimental group also showed a decrease in the number of errors that indicated sound reasoning but the arrival at conclusions that were not entirely justified. These findings are noteworthy and encouraging since advanced logical reasoning ability is integral to all post-secondary disciplines, and the experimental group was able to demonstrate cognitive transfer to a deductive reasoning ability test after only a week of intense interaction with the computer game -- an use of technology to enhance learning.

Example 3: A Planning Framework for Enhancing the Acquisition of Language Ability

This example is intended to discuss the ways in which instructional strategies using technology might focus on a specific skill or ability -- in this case, language acquisition. Continued development of language and communication abilities beyond high school is fundamental to higher order learning in virtually every college discipline or field of study.

In and of itself, the language domain is complex in that there are many different aspects of knowing and using a language. Language abilities can be grouped according to the following eleven principal clusters: (1) language development; (2) language comprehension; (3) lexical knowledge; (4) reading comprehension; (5) reading speed; (6) phonetic coding; (7) grammatical sensitivity; (8) foreign language aptitude and proficiency; (9) communication ability; (10) oral presentation; and (11) writing ability (Carroll, 1993). In college, some of the more typical tasks in the language domain include note-taking, encoding phonetic and semantic information, comprehending and conveying complex ideas, developing a vocabulary of terms that are unique or germane to a particular field, and constructing conceptual knowledge to communicate abstract thoughts and principles. Learning, then, can be enhanced by instructional technologies that assist students in the mental operations associated with these tasks.

Factoring the ways in which technology can maximize learning outcomes into technology planning is particularly relevant to the community colleges because its students, including adult learners, are more diverse with respect to entering abilities than is typically the case with students who are among the top third of high school graduates. However, students at all performance levels can benefit appreciably from educational technologies that assist them in manipulating, connecting, discovering, and understanding complex ideas and thoughts.

For example, if a particular technology initiative was intended to assist learners in constructing conceptual knowledge, then planning should focus initially on the general class of human abilities and operations associated with the acquisition of conceptual knowledge and the related cognitive models and theories that best explain the ways in which such knowledge is mentally represented. Based upon theories as to the manner by which individuals construct conceptual knowledge, educational courseware developers can discover and develop practical applications of technology to support the acquisition of this skill.

Similar theoretical underpinnings should guide the use of technology in supporting the achievement of specific learning outcomes. Since any particular outcome will usually require a range of skills and abilities, it follows that the greater number of abilities expected to be enhanced through technology, the greater the possibility that learning will be maximized. Perhaps the greatest challenge facing postsecondary educational administrators and educators will be determining which of the hundreds of important theories on cognition and learning might be most useful for planning purposes.

Factoring the ways in which technology can maximize learning outcomes into technology planning is particularly relevant to the community colleges because its students, including adult learners, are more diverse with respect to entering abilities than is typically the case with students who are among the top third of high school graduates. However, students at all performance levels can benefit appreciably from educational technologies that assist them in manipulating, connecting, discovering, and understanding complex ideas and thoughts.

Summary

This section has described some of the ways in which technology can support learning both indirectly -- through increased access to knowledge resources and expanded collaborative arrangements -- and directly by focusing on specific cognitive skills and abilities. While the literature clearly supports a conclusion that positive benefits are derived from increased student access to information, some uncertainty and debate continues regarding the unique contribution or improvement in learning outcomes that can be directly attributed to technology when other aspects of the learning process are controlled. Part of this uncertainty stems from research findings which indicate that the effect of technology on learning is not necessarily uniform across all situations and learning experiences. While several examples were cited illustrating the use of technology to directly affect learning in some domains, there are still questions regarding the generalizability and scalability of such findings to other learning domains. Additional research is needed to determine more precisely the most optimal uses of technology for varying learning tasks.

The Commission believes that as public, independent, and private postsecondary education institutions continue technology planning activities consistent with their respective missions, specific attention should be given to ways of improving student cognitive abilities. Educational technologies can offer extensive possibilities for improving teaching and learning but only if it is an explicit goal to be pursued. The Commission encourages that all initiatives to improve teaching and learning be accompanied by appropriate research studies to assess the effectiveness of various applications in achieving the desired learning outcomes.

Next steps

To continue the discussion of higher education and technology, the Commission will convene a broad advisory committee consisting of representative from the systems, state policy makers, and experts in educational technology. From time to time, individuals with specific expertise may be asked to participate on the committee, and it is possible that other committees with specific assignments may spin off from it. The Commission hopes to have this committee in operation this year, and to develop a third report with specific recommendations before 1997 is over.

While this effort is in progress, most of the rest of the Commission's activities will serve to expand this analysis, including studies of eligibility of students for the State University and the University, student fees and financial aid, governance, accountability, and long-range planning. In the end -- if such a thing as finality in an age such as this can be conceived -- it is hoped that California's institutions of higher education will find better and more efficient ways to conduct their business, that the pressing demands for enrollment by the sons and daughters of the "boomers" will be satisfied in new and creative ways, and that improved learning outcomes will become evident.

Appendix A A Glossary of Technological Terms

THE NUMBER of terms commonly used to describe the technology of modern times is often bewildering, yet continues to expand rapidly. The following list is therefore not intended to be inclusive, but should afford the reader with a sufficient amount of information to understand most of the language that is used most often.

Accelerator

A circuit card containing electronic components designed to be plugged into a computer to make it run faster.

Access Time

The amount of time it takes a computer to locate an area of memory for data storage or retrieval.

AI

Artificial Intelligence -- the field of computer science dedicated to developing computers that mimic the complex relational functions of the human brain. Expert systems are an early form of AI.

Algorithm

Any computing process that uses a well-defined series of steps to predictably solve a particular kind of problem. In programming, algorithms are used as either a specific solution or a starting point for experimentation.

Alpha Testing

Conducted internally by the manufacturer, alpha testing takes a new product through a protocol of testing procedures to verify product functionality and capability.

Analog

A process or device which represents or calculates data in a continuously variable form rather than in separate steps.

Anonymous FTP Site

A public FTP server that can be accessed by any user of the Internet.

Application Software

A computer program or system designed to perform specific tasks. Broad examples of computer applications are word processing and graphics programs such as Microsoft Word(TM), QuarkXPress(TM) and Adobe Illustrator(TM).

Architecture

Refers to the physical configuration of a computer's internal operations, including memory, input/output structure, instruction set and registers. The term is alsoused to describe the specific components and the interactions that form a computer system.

Archival Storage

Copies of digital information stored on magnetic tape, floppy disks, optical disk, CD-ROM or other media used to ensure against loss in case the original materials are deleted or damaged.

ARPANet

Advanced Research Projects Administration Network. This was the precursor to the Internet. ARPANet was developed in the late 1960s by the Department of Defense as an experiment in wide-area networking that would survive a nuclear war.

Array

A table of numbers or text which the computer holds in its memory—used in programming, a list of data values, all the same type.

Array Processors

Identical processors connected together and acting synchronously, often under the control of a CPU. Some systems use array processors for high-speed floating point math operations to speed up video operations.

ASCII

American Standard Code for Information Exchange. This is a world standard for the codes used by computers to represent the characters of the alphabet and numbers, etc. There are 128 ASCII codes which are represented by an eight-digit binary number: 00000000 through 11111111.

Asynchronous Communication

Also known as serial communication. A way for one computer to send data to another without requiring precisely synchronized data pulses. Special codes are embedded in the stream of pulses so that the receiving computer can locate each byte of data.

ATM (Asynchronous Transfer Mode)

A switching protocol that can handle all types of traffic -- voice, data, graphics, and video.

@

Used to separate the user ID and domain name of an Internet address (pronounced "at"). Authentication Security feature that determines a user's identity and legitimacy.

BBS

Bulletin board system; once referred to stand alone desktop computers with a single modem that answered a phone, but can now refer to systems as complicated and interconnected as commercial services.

Backup

The process of copying a file or program in the event the original is damaged, lost or unavailable. Bandwidth The data transmission capacity of a network, used colloquially to refer to the size of the Net; some information transmittals; some information (for example, a multitude of graphic files) are considered a "waste of bandwidth."

Bandwidth

A measurement of how much information can be sent through a network connection in a given time interval. Bandwidth is usually measured in bits per second (bps).

Baud

A measure of the rate by which data is transmitted and is most commonly used in rated modems. Expressed in bits per second, one baud equals one bit per second.

Beta Testing

The second stage test version of a newly developed piece of hardware and/or software which is distributed free to a limited sampling of users so that they can subject it to daily use and report any problems to the manufacturer before release to the public.

Binary

The base-two numbering system which uses only the digits 0 and 1. It is the format for processing data in computers.

BINHEX

BINary HEXidecimal. Binhex is a method for converting non-text files (non-ASCII) into ASCII. This is relevant because Internet E-mail is ASCII.

Bit

Abbreviation for "binary digit." Internally, computers store information as patterns of ones and zeros. Tiny transistors are either "on" (storing a value of "1") or "off" (storing a value of "0"). The digits "1" and "0" are "bits"—the smallest pieces of information a computer can handle.

Bitmap

A computerized image made up of dots. In the simplest form of bitmap, each dot is either on (white) or off (black) and is stored as a single "bit" of information in the computer's memory.

BITNET

Because It's Time NETwork. A network of educational sites separate from the Internet, although E-mail is freely exchanged between BITNET an the Internet. Listservs, the most popular form of E-mail discussion groups, originated on Bitnet. Bitnet machines are IBM VMS machines. Bitnet usage is declining as the WWW expands.

BPS

Bits per second.

Browser

Software that allows users to "browse" the World Wide Web. Browsers include Mosaic, Netscape Navigator, and Microsoft Internet Explorer. Services such as American OnLine are not browsers but provide access to browsers.

Buffer

A segment of computer memory used as a temporary data storage area, used to provide a flexible data bridge to smooth communication between parts of an operating system that have different data transfer rates.

Bulletin Board

An electronic information and data transfer service that can be accessed through the telecommunications network from any computer terminal configured with a modem and telecommunications software.

Bus

The main "data pathway" inside a computer enabling the CPU to communicate with other devices, such as the video monitor or the disk drive(s).

Byte

A unit of information consisting of a sequence of eight adjacent binary digits (bits) and usually sufficient to store one character of information.

CCD

Initials standing for "Charged Coupled Device." An array of light-sensitive solid-state measuring devices that react electronically to exposure of light. It is the technology used most often in desktop scanners.

CD-ROM

Compact Disk-Read Only Memory. A medium for storing 670 megabytes of digital information that can be retrieved repeatedly but cannot be changed.

CERN

The European Particle Physics Laboratory in Geneva, Switzerland; the organization responsible for creating the World Wide Web.

Chip

A small electronic component containing a chip of silicon on which many miniaturized transistors and other devices have been etched. Microprocessors are largely made up of chips.

Circuit Board

Also referred to as a "board" or "card." A rectangle of thin plastic with electronic components mounted on it. It plugs into a computer's bus to add a feature or function that is not otherwise available. For example, a video card may give a computer additional capability for displaying colors.

Client

A computer connected to a more powerful computer (see server) for complex tasks.

Clone

A copy. In microcomputer terminology, a clone is a look-alike, act-alike computer that contains the same microprocessor and runs the same programs as a more expensive, better known name brand. Although a clone is supposed to be exactly alike, in some instances there may be small internal variations that can cause operating problems without the manufacturer's assistance.

Commercial Services

General term for large commercially-oriented online services (e.g. America Online, CompuServe).

Communications Protocol

The preliminary signals and settings (handshake) that must be shared by two computers before data can be exchanged between them, usually via a modem. A typical communications protocol will establish the speed of the data flow in bps, error-correction methods that will be used (if any) and data compression systems (if any).

Compression

The use of special coding techniques so that data can be stored more compactly in order to reduce the amount of room it takes to be transmitted to a modem or via another transmission method.

Configuration

The special assemblage of components and devices that make up the hardware parts of a complete system.

Console

An electronic workstation that includes a video monitor.

Control Character

In an alphanumeric code, it alters the meaning of the codes that follow it until another control character is used. Usually this signifies what follows should be regarded as a command rather than data.

Conventional Method

Describes the manual process of producing a job. CPU Central Processing Unit. In a modern microcomputer, is generally a single silicon chip which acts as the "brain" of the computer by performing fundamental arithmetic operations and moving bytes of data inside the computer's memory.

Cracker

A person who maliciously breaks into a computer system to steal files or disrupt system activities; not to be confused with hacker.

Cursor

A location marker on a computer screen controlled by a mouse or directional keys on the keyboard. It can be an underline, rectangle, cross, arrow, or other special indicator.

Cyberspace

A term originated by author William Gibson in his novel *Neuromancer*, the word currently describes the range of information resources available through computer networks.

Data Shift

In process color printing, it describes a shift in one of the channels of data that comprise the image file and could cause inconsistent color in some area in the image.

DDES

Direct Digital Data Exchange Standards. A set of established formats, protocols and values allowing one vendor's equipment to exchange data with another vendor's equipment.

Dedicated Device

A piece of hardware that is permanently assigned to one task. The task however, can be changed by reprogramming or by the introduction of different software.

Dedicated Link

An exclusive port dedicated for a dial-up IP account.

Dedicated System

Describes the permanent assignment of an entire electronic system to one task.

Default

Software setting that returns specifications to a relative "home-base" in the absence of other instruction from the operator. Depending on the software, new default settings can be made for one or more functions.

Desktop Publishing

Sometimes abbreviated DTP. The process of mixing type and graphics via a microcomputer to create and control page layouts and save them in a form that is portable to various types of printing equipment.

Device Driver

A miniature program that acts like a translator, converting the output from one device into data that another device can understand.

Device Independent

A program or file format that can be used with two or more different computing devices and produce identical results. For example, a page saved in PostScript format should be printable on a LaserWriter or on a Linotronic output device. Device independent color refers to the ability to have color images appear the same on different output devices, including monitors and printers.

Dial-up link

Also called a switched line, a dial-up link is a low-cost connection to the Internet through a non-dedicated communications line.

Digital

Information that relies solely on Arabic numerals for expression. In computers, all information is processed in binary numerics (0 and 1) through on/off electrical impulses. Computer programs are written in alphanumeric code (all keys on a keyboard) and are translated by programs or devices into binary code that can be read by the CPU of the computer.

Disk Drive

An electronic device that through a read-write head, can store information on, or read from, a magnetic disk.

Disk Operating System

Often abbreviated "DOS," a kind of low-level program which must be present in the computer's memory at all times while the computer is running, in addition to any other programs that are being used. The system (known as DOS in PC-compatibles or The Finder on a MacIntosh) manages all disk operations.

DNS

Acronym for Domain Name System. The distributed naming service used on the Internet.

DNS Server

A server that contains IP addressing information.

Domain

The highest subdivision of the Internet, which are usually by country or type of entity (for example, government or commercial). DNS organizes groups of computers on the Internet through a hierarchy of domains.

Domain Name

The unique name that identifies an Internet site. Domain names always have two or more parts, separated by dots. The part on the left is the most specific; the part on the right the most general. Middle sections of the name fall, appropriately, somewhere between the two extremes of specificity (e.g. cpec.ca.gov)

Download

The transfer of data from a computer or telecommunications network to another electronic device or storage medium.

DPI

Dots Per Inch. The measure of resolution in a halftone or printed image. It is also used to describe pixels per inch in a bitmapped image.

DSU

Acronym for Data Service Unit. The side of the communications channel equipment connected to the bridge or router. It converts all incoming data into the proper format for transmission over the T1 or fractional T1 circuit.

E-mail

Electronic mail, as distinct from paper mail (which is known in Net parlance as snail mail). A network service that enables users to send and receive messages. Electronic Publishing A technology through which information (text and images) that has been converted to digitized form can be processed in an interactive electronic environment.

EPS

Encapsulated PostScript. A way of storing visual data so that it can be exchanged between programs or different computer systems. When you save in EPS format, you save a description of your art or page layout in the PostScript language together with some minimal instructions enabling the graphics to be displayed on a non-PostScript video device.

Encode

The term used to describe the translation of information, such as text or photographs, into binary code.

Encryption

A method of securing privacy on networks through the use of complex algorithmic codes.

Ethernet

A local area network (LAN) hardware standard capable of linking up to 1,024 nodes.

Exabyte

An eight-millimeter, two-gigabyte tape drive providing substantial data storage and archiving on a small cartridge. It is more cost effective than standard magnetic tapes as fewer Exabyte tapes are required to store information.

Expansion Bus

The main "data pathway" inside a computer, usually fitted with slots which will accept circuit cards to expand and enhance the capabilities of the computer.

Expansion Slot

A long, thin socket mounted in an expansion bus which accepts an expansion card.

Export

To move data in a form that another program can read.

FAQ

Frequently asked questions, a list of questions and answers that is the most common means of reducing the number of newbie requests in online discussions.

File Fragmentation

The condition in which, as a consequence of enlarging files and saving them on a crowded disk that no longer contains contiguous blocks of free space to hold them, saves them as fragmented parts in separate areas of the disk and ultimately slows down read-write access time.

File Server

A powerful microcomputer containing programs and data which may be accessed by other microcomputers that are linked with it via a network.

Firewall

A feature that protects a network connected to the Internet from being accessed by unauthorized users.

Flame

A violent and usually personal attack against another person in a news group or other area for public messages.

Floppy Disk

A thin, flexible plastic disk which has been coated with iron oxide and is capable of storing computer data as a magnetic pattern. Floppy disks are a convenient way of saving data or swapping information for use on another computer.

Font Bitmapping

A bitmapped rendering of a screen font.

Frequency

The lines per inch (lpi) in a halftone screen.

Freeware

Free software, not to be confused with shareware.

Front end

A program that improves the appeal and ease of use of other programs, normally run locally on a user's computer.

Front-End System

A workstation or group of workstations that provide one or more operators with the ability to interact with a large scale computer system. For example, a MacIntosh computer is a front end for a mainframe.

FTP

File transfer protocol, a method for accessing file archives and transferring files over the Internet.

Gamut

The common expression for the entire range of color that can be shown on a computer display.

Gateway

A connection in the form of a cable, device or computer between two computers or systems that are similar.

GIF

Graphics interchange format, a common file format for pictures first popularized by CompuServe (pronounced with a hard "g").

Gigabyte

Abbreviated as Gb or GB, it equals approximately one billion bytes or a thousand megabytes.

Gopher

A menu-based protocol that allows clients to access files and directories across the Internet.

GPIB

General Purpose Interface Bus. An interface bus standard recognized by the Institute of Electrical and Electronics Engineers (IEEE).

Graphic Input Device

An electronic device that digitizes and converts images into a bitmapped image that a computer can manipulate. A scanner converts two-dimensional images; a video camera converts three- dimensional images.

Graphic Output Device

An electronic device that converts a bitmapped image into soft or hard reproductions. A video monitor is a soft output device; image setters are hard output devices.

Graphic Tablet

An electronic device that converts the instructions of the operator through a mouse or stylus into code that the computer can read as commands for direct interaction with the display monitor. Among the tasks that can be accomplished by moving the mouse or stylus on the tablet are computation and display of coordinates, placement and manipulation of image elements and operation of menu items.

GUI

Graphical user interface, an interactive screen display that provides icons, windows, and point-and-click capability, as distinct from a command-line interface that require typed instructions.

Hacker

A computer enthusiast who explores computer systems and programs to the point of obsession; not to be confused with cracker.

Handshake

The protocol used by two computer systems to establish communication.

Hard Disk

A mass storage device for digital data. One or more magnetic platters in a single casing. It can store data more precisely and access it more quickly than other forms of magnetic storage.

Hard Copy

A printed paper copy of output in readable form. It is also a transparency film or photograph of an image displayed on the monitor.

Host

Any computer system or device attached to the Internet.

Home Page

The first page of a Web site.

HTML

Acronym for Hypertext Markup Language. The scripting language used to create Web documents.

HTTP

Acronym for Hypertext Transport Protocol. The network protocol used by the World Wide Web.

Hypertext

A link between one document and other, related documents located elsewhere. By clicking on a word or phrase that has been highlighted, a user can skip directly to files related to that subject.

Icon

A thumbnail-sized picture representing an application, file or document.

I/O Input/Output Image

The digitized representation of a graphic element (photograph, painting, film) bitmapped in computer memory for display on a video monitor for output in paper or film form.

Image Enhancements

Electronic functions such as shading, coloring and highlighting that accent an image or a portion of an image.

Image Processing

The manipulation of an original image from digitization through manipulation to output on a plotter, printer, image setter or plate setter.

Import

To merge text or graphics into a document that is being created or edited with the aid of a computer program. Usually, the imported file is generated with a different program.

Inkjet Printer

An electronic output/proofing device that prints by spraying streams of ink onto the paper.

Installation

The process of delivering, setting up and testing a complete or partial electronic system at a site specified by the purchaser.

Interface

The hardware and software that enable electronic devices to share information.

Internet

The world's largest collection of networks with an estimated 30 million users reaching universities, government research labs, military installations and business organizations in many countries.

Internet Service Provider

A company or other organization that offers connections to the Internet through its own computers, which are part of the Internet.

Intranet

An internal corporate Web site. Intranets are either not connected to the Internet or are shielded from external Internet users by a firewall.

IP Number

Sometimes called a "dotted quad." A unique number consisting of four parts separated by dots (e.g. 165.113.245.2). Every machine that is on the Internet has a unique IP number -- if a machine does not have an IP number, it is not really on the Internet. Most machines also have one or more Domain Names that are easier for people to remember.

IPX

Acronym for Internetwork Packet Exchange. Default protocol used by NetWare systems to route information packets over a local or wide area network. IPX has the same functions as TCP/IP.

IRC

Internet relay chat, real-time conversations among multiple users on hundreds of subject-oriented channels ranging from #nfl to #12-step to #wetfun (popular chat channels).

ISDN

Acronym for Integrated Services Digital Network. A new telecommunications standard being introduced by telephone companies. It enables the transmission of voice, data, and certain images over telephone lines through end-to-end digital circuits.

ISO

International Standards Organization.

Kilobyte

K, Kb or KB. A unit of measuring digital information which equals 1,024 bytes.

LAN

Local Area Network. A pathway that links workstations, printout devices and storage units through broadband cable and provides high-speed simultaneous communication in a relatively small area.

LaserPrep

A set of commands that translates most MacIntosh text and graphics files into PostScript files.

LPI

Lines per inch.

Luminosity

A value corresponding to the brightness of color.

Lurker

A regular reader of online messages who never sends a post.

Low Res

Abbreviation for low resolution.

Lynx

A popular text-based Web browser.

Macro

A series of keystrokes that can be called up by pressing one special key combination. Many word processing programs allow the user to create macros to speed up complex operations that are frequently used.

Megabyte

Mb or MB. A unit of measure for digital data which is 1,024 kilobytes or 1,048,576 bytes.

Microprocessor

The silicon chip with thousands of electronic components that serves as the central processing unit (CPU) in microcomputers.

MIPS

Millions of Instructions Per Second

Modem

An abbreviation for modular/demodulator, a device that translates digital signals into sound frequencies and back again for telephone transmission.

Motherboard

The assembly in a computer into which printed circuit cards, modules or boards are connected. In a microcomputer, this is the main circuit board.

MPEG

Moving pictures expert group, an international standard for video compression and desktop movie presentation, required to view movies on a computer.

Multitasking

Running two or more computer programs simultaneously.

MUD

Multi-user dimension or multi-user dungeon, a virtual world created solely from text descriptions by many users, with applications ranging from role-playing games to academic conferences.

Net

A colloquial term used to refer to the entirety of cyberspace including, for example, the Internet, commercial services, and BBS's.

Netiquette

The rules of cyberspace civility, enforced exclusively by fellow users.

Newbie

A newcomer to the Internet.

News Group

A public bulletin board on the Internet; collectively, the more than 12,000 news groups, organized by subject, are known as Usenet.

Networking

The process of accessing and manipulating files through communication pathways between workstations, printout devices, such as print servers and storage units, such as file servers.

NSFNET

A network that serves as part of the current Internet backbone funded by the National Science Foundation.

Noise

Unwanted electronic or optical signals that cause interference in the reproduction of data or images.

Object-Oriented

A type of drawing that defines an image mathematically rather than as pixels in a bitmap.

OCR

Optical Character Recognition. A function of specialized software capable of interpreting a scanned image of text into machine code for later manipulation of text.

Off-Loading

Relieving the intensive amount of data processing associated with a specific application from the CPU by performing those calculations in a dedicated or specialized processor.

Off-line Storage

Storage of digital data on devices separate from the main system.

One-Bit Image

An image with only black and white pixels.

Operating System

The essential software that directs the flow of information to and from the different components of a computer system.

Optical Disk

A type of high-capacity computer storage disk which stores information in a mode similar to CD-ROM but is erasable and reusable.

Output

Information that has been manipulated by the CPU of the computer and displayed either on the video monitor or rendered as usable information by another device.

Output Resolution

Stated in lpi or lines per millimeter, output resolution reflects the number of pixels per unit size that can be output.

Parallel Transmission

Sending data from a computer down several wires simultaneously, the pulses in one wire being precisely synchronized with the pulses in the other wires.

PDL

Page Description Language.

Peripherals

A connectable device that has an auxiliary function outside of the permanent system configuration.

PICT/PICT-2

A picture file format developed by Apple for use on the MacIntosh. The format defines bitmapped or object-oriented images on the screen. PICT-2, a more recent version, supports 24-bit color.

Pixel

The abbreviation for picture element. The separate elements of a bitmapped image on a video monitor.

Pixelate

The electronic function by which pixel size can be increased to enable easy manipulation in creating special effects.

Point of Presence

A POP is the regional hub by an Internet Service Provider to connect networks.

PPI

Pixels per inch.

Port

A socket, usually at the back of a computer, that allows the computer to be connected to other devices.

PostScript

A page-description language (PDL) developed by Adobe Systems. When a page is stored as a set of instructions specifying the measurements, typefaces and graphic shapes that make up a page.

PPP

Point-to-Point Protocol connection between a computer and the Internet, offering advantages over dial-up access such as support for a graphical Web browser (for example, Netscape) and simultaneous multiple connections; requires special software and a PPP service provider.

PPD File

PostScript Printer Description File. A file that contains information on screen angle, resolution, page size and device-specific information for a file to be printed on a PostScript device.

Print Engine

A mechanism that uses a laser to create an electrostatic image of a page and transfers it to a sheet or roll of paper.

Queue

A multi-element data structure from which elements can be removed only in the same order in which they were inserted; in a priority queue, removal is based on factors other than order of insertion -- removed according to some priority value assigned to each.

RAM

Random Access Memory. The memory a computer needs to store the information it is processing at any given moment. This is short-term memory and is lost when the power is shut off.

Rasterization

The process of converting mathematical and digital information into a series of dots by an imagesetter or recorder as digital data that will be used for output.

Read

The process by which the CPU is instructed to find specified digital data for display or output.

Real-time

The Net term for live as in "live broadcast;" real-time connections include IRC and MUDs.

Refresh

The process by which more information is brought to the video display after an alteration or other action.

Repagination

The process used to change page numbers in multi-page documents while retaining a uniform format and proper numerical sequence.

Repeatability

The precision with which a device can position an image, usually measured in microns. For example, a capstan imagesetter has low repeatability compared with a drum imagesetter which is more accurate in its operation.

Resolution

The number of pixels per unit of linear measurement on a video display or the number of dots per inch in printed form.

RGB

Red, Green and Blue. The additive primaries which are used in video monitors.

RIP

Raster Image Processor. The hardware/ software which converts data stored in a computer into a series of lines of tiny dots which are output to film, proof, plate or printer. In line work, the dots can be grouped to create solid areas. RIPing is most commonly associated with the conversion of a PostScript File to a "raster" that can then be imaged by the imagesetter.

ROM

Read Only Memory. The computer memory that can be read by the CPU of the computer but cannot be altered.

Router

A special-purpose computer (or software package) that handles the connection between two or more networks. Routers connect local area networks to wide area networks, creating an internet (small i, simply a combination of any two other networks). Routers are used extensively on the Internet (capital I, the global network successor to the ARPANet).

Scanner

An input device that digitizes and converts two-dimensional information, such as photographic prints, transparencies and paper images into bit-mapped images that can be manipulated electronically.

Screen Angle

The angles used to offset the different patterns for overprinting each other in process color printing. Proper angles are critical to the prevention of moirÈ patterns.

Screen Ruling

Sometimes confused with resolution, screen ruling is the number of printing dots per millimeter or per inch on the exposed film. The screen ruling is a critical factor in determining the resolution need. The finer the screen ruling, the higher the resolution needs to be, due to the amount of information required to generate the printing dots.

SCSI

Small Computer Standard Interface. An industry standard enabling external devices, such as a disk drive, to be plugged into a computer made by any manufacturer whose product conforms to the SCSI specification.

Sectors

Divisions on magnetic media used for storing digital information. A single sector is the smallest contiguous unit of information; multiple sectors make up a track.

Sequential Storage

Recording data in a linear mode, stringing codes sequentially on a magnetic tape. Although it is a less expensive storage form, it is a more time- consuming method of retrieval.

Serial Communication

See asynchronous communication.

Server

A computer connected to a network that offers various services, such as document viewing or file transfers, to other computers called clients.

Service Bureau

A company that provides the various services required to transform the elements used to produce a page or publication into the correct digital format required to output it to a particular chosen media. These include conventional print, various forms of direct digital printing, disk-based and other forms of alternative media.

Shareware

Freely distributed software, often available from vast FTP archives on the Net, that includes a request from the programmer for voluntary payment.

Sharpen

The electronic manipulation of an image to alter the edge contrast of its elements.

SLIP

Serial Line Internet Protocol connection between a computer and the Internet, offering advantages over dial-up access such as support for a graphical Web browser (for example, Netscape) and simultaneous multiple connections; requires special software and a SLIP service provider.

SMTP

Simple mail transfer protocol, an e-mail protocol used to transfer e-mail from one serve to another fro distribution to the appropriate client.

Soft Proof

A proof that is viewed on a color-calibrated video monitor as opposed to a hard proof on paper.

Spam

The posting of an article to many newsgroups, regardless of the appropriateness of the topic; for example, "You can grow rich overnight."

Spectrum

The bands of color formed when white light is dispersed. Each color has a specific wavelength from the shortest -- violet, to the longest -- red.

Spooler

A method by which a computer can store data and feed it gradually to an external device, such as a printer which is operating more slowly than the computer.

Stripping

The process of manually creating composite films and fully imposed flats for plate-making. Most of this work is being done electronically, bypassing the traditional craftsman.

Style sheet

A list of page format specifications including typographic and layout specs. In desktop publishing, a style sheet can be stored, retrieved and applied to individual elements of the page displayed on the screen.

System

An integrated assembly of electronic hardware and software designed to implement a given application or set of applications.

T-1

A leased-line connection capable of carrying data at 1,544,000 bps. At maximum theoretical capacity, a T-1 line could move a megabyte in less than 10 seconds. That is still not fast enough for full-screen, full-motion video, for which you need at least 10,000,000 bps. T-1 is the fastest speed commonly used to connect networks to the Internet.

T-3

A leased-line connection capable of carrrying data at 45,000,000 bps, more than enough for full-screen, full-motion video.

TIFF

Tagged Image File Format. A graphics and page layout file format for desktop computers. Used as an intermediary file format for both color and black and white images, TIFF is used to transfer documents between different applications and computer platforms.

Tape Drive

An electronic device that can read or write information on a formatted magnetic tape.

Task Switching

A feature offered by some disk operating systems allowing the user to copy two or more programs into computer memory at the same time so that the user can switch quickly from one program to the other. This is different than multitasking in which programs not only reside in memory simultaneously, but may be used simultaneously.

TCP/IP

Acronym for Transmission Control Protocol/Internet Protocol. Default protocol used by UNIX systems to route information packets over a local or wide area network. The standard protocol upon which the Internet is based.

Telnet

An Internet program that allows a user to log on to other Internet-connected computers.

Terabyte

Tb or TB. Equal to approximately one billion kilobytes and often used to measure optical disk storage capacity.

Tiling

An electronic function for use with documents that are larger than the specified paper size. The document can be broken into sections the size of the paper and then assembled.

Tracking

Small, uniform adjustment to the amount of space separating adjacent typeset letters.

Trade Shop

A company that serves the printing "trade." Often referred to as "color separators," many trade shops have expanded services and markets and are more appropriately designated as prepress trade shops or service bureaus.

TCP/IP

Transmission Control Protocol and Internet Protocol that forms the basis of a full fledged Internet connection.

Trap

An overlap or underlap between colors that butt against each other to hide misregistration during printing. Types of traps include shrinks (chokes) and spreads.

Turnkey System

A completely integrated computer system that includes all the hardware and software necessary to perform specific tasks.

UNIX

An operating system often implemented on high-powered workstations. It has advantages in situations where one computer serves many users or where two or more tasks must be executed simultaneously on one computer.

URL

Uniform Resource Locator, the World Wide Web address of an Internet resource; for example, GE's URL is http:/ /www.ge.com.

User Interface

The method by which a user gives instructions to a computer and receives a response.

USENET

A distributed, Internet-wide bulletin board system that is the basis of network news.

Vector Graphics

Object-oriented graphics in which an image is stored as a series of numbers defining size, position and shape. Such objects must be "rasterized" prior to processing for output.

Veronica

Very Easy Rodent Oriented Net-wide Index to Computerized Archives. Developed at the University of Nevada, Veronica is a constantly updated database of the names of almost every menu item on thousands of Gopher servers. The Veronica database can be searched from most major gopher menus.

Virtual Memory

The use of a portion of the hard disk to swap-out data when insufficient RAM exists to hold all such data.

Virus

A small program, commonly embedded in another program, that infects programs and causes them to malfunction. It is often designed to destroy data and infect other programs, drives and disks.

WAIS

Wide Area Information Servers. A commercial software package that can index huge quantities of information, and then make those indices searchable across networks such as the Internet. A prominent feature of WAIS is that the search results are ranked ("scored") according to how relevant the "hits" are, and that subsequent searches can find "more like this" and thus refine the search process. WAIS is a prominent feature in such search engines as Excite and Yahoo.

WAN

Acronym for Wide Area Network. A physical communications network that operates across large geographical distances.

Web Browser

A client program that enables the viewing of Web pages, the most popular Web browsers are Netscape Navigator and Microsoft Internet Explorer.

Web Page

A hypertext document available on the World Wide Web that can incorporate graphics, sounds and links to other Web pages, FTP sites, gophers, and other Internet resources.

Windows

Transparent areas that show space allocated for an image on a video display of a page layout. Also, an operating system marketed by Microsoft Corp. for use on PC-compatibles to offer a graphical user interface similar to that of Macintosh.

Workstation

A configuration of computer equipment designed to be used by one person at a time. A workstation may have a terminal connected to a larger computer or may be independent with local processing capability. In four-color process printing, it usually consists of an input device such as a keyboard, digitizer or scanner, a video display device, a memory and an output device such as a printer or plotter.

World Wide Web

A hypermedia-based system on the Internet that is navigated by selecting hypertext links between text or graphics and other Web pages or Internet resources; also called Web or WWW.

WORM

Write Once/Read Many. It refers to the permanent, unalterable nature of data in certain kinds of storage media.

Zoom

An electronic function that increases or reduces the magnification of the image displayed on the video screen.

Appendix B A Short Course on the Internet

Introduction

The Internet is the commercial, social, public, and private phenomenon of the 1990s. Virtually unknown to the general public only a year or two ago, it has become an integral part of common parlance almost overnight, with "web" addresses appearing constantly on television, billboards, and other advertising, and spoken of just as constantly on the radio.

What is the Internet? Where did it come from? Who owns it? How do we get to it? Does the government regulate it? Why is everybody so excited? These and other questions are answered, at least in part, in the following narrative.

How the Internet Came to be?

The Internet began in 1962 at the height of the Cold War as a way to maintain communications in the event of a nuclear attack. The Rand Corporation, a defense contractor, noticed that existing defense communications networks were chained in a point-to-point system that could be disrupted or even destroyed if one of the links in the chain was destroyed. Paul Baran of Rand believed that this problem could be obviated with a new system that was organized more like a grid than a chain. With such a network, information could move from point A to point B by any one of a number of routes, which meant that the destruction of one part of the grid did not take the entire grid down. At the time, Baran's idea was considered revolutionary, with the result that the Defense Department shelved his 11-volume report, but other researchers and thinkers in the department thought he had hit on something truly important, and consequently kept his idea alive.

In 1965, the Defense Department's Advanced Research Projects Administration (ARPA) sponsored further research into Baran's idea, calling it a "cooperative network of time-sharing computers." That led in 1967 to a symposium on the subject, and the first concrete plans for ARPANET. This was implemented in its first crude form in 1969 by establishing computer centers at four sites: the Stanford Research Institute, the University of Utah, and the University of California campuses at Los Angeles and Santa Barbara. For the first time, it was possible to exchange information among these four sites even if a link between two of the sites was broken. Although not yet termed the "Internet," the creation of these four computers marks the true beginning of the massive network in operation today.

The ARPANET was an instant success, and while its original purpose was to exchange large amounts of information, electronic mail (e-mail) was soon added and became its most popular feature. By 1971, there were 23 sites in operation, and by 1973, the ARPANET had gone international with connections in England and Norway. Then, given the increasingly evident need to create standards for datatransmission and other items, a group known as the InterNetworking Working Group was formed under the leadership of Vinton Cerf, its first chairman, who later came to be known as "the father of the Internet."

Throughout the 1970s, the ARPANET grew in both size and function, with a few commercial applications being added, and growing interest expressed by numerous colleges and universities. By 1981, there were 213 host computers -- called "web sites" today -- with a new site being added every 20 days, but this was just the beginning of the subsequent technological revolution. In 1982, the term "Internet" was used for the first time, as Bob Kahn and Vinton Cerf, with others, created the transmission protocols (TCP/IP) that made the Internet possible. A description of those protocols (e.g. ftp, http, html, etc.) is contained in Appendix A. Once in place, and with the explosion in computer technology that occurred in the 1980s, many corporations began to see the huge commercial potential of the Internet and started to use it to communicate with each other and with their customers.

The size of the network accelerated dramatically in the 1980s. In 1984, the term "cyberspace" was coined by William Gibson in his novel *Neuromancer*, at a time when the total number of Internet sites exceeded 1,000 for the first time. Three years later, there were 10,000 sites world wide; within only one more year, 50,000 more sites were added. By 1990, there were 300,000 sites or "home pages." In that year, ARPANET was officially decommissioned by the Defense Department, leaving only the network of networks known as the Internet.

The Internet as it is known today experienced a truly seminal event in 1991. The backbone network of the Internet -- the network of networks -- had always been NSFNET, the network of the National Science Foundation, which prior to 1991 had prohibited commercial transmissions. When this ban was lifted, the commercialization of the Internet became possible for the first time. However, other problems remained, among them the problem of locating useful information in a network already so large and now growing so rapidly. It was similar to the problem experienced by telephone communications in the late 19th century prior to the introduction of telephone directories and the yellow pages.

The first effort to introduce a "yellow pages" for the Internet was "gopher," the first point-and-click search engine. It was extremely limited by today's standards that feature such search engines as Alta Vista, Excite, Magellan, and Yahoo, yet the need was so great that it was an instant success. Nevertheless, the Internet remained difficult to use and still existed primarily as a network for transmitting text. That soon changed with the introduction of graphics, the invention of "browsers," and the creation of the "World Wide Web."

A group of students working at the University of Illinois' National Center for Supercomputing Applications (NCSA) at Urbana/Champaign saw the Internet's potential as a communications medium and invented the first browser, which they called "Mosaic." The need was evide[illegible] the number of host sites passed the one million mark. By 1993, the World Wide Web, or just "web," had become the basic

Internet platform, Mosaic had become widely available, and the Internet had become a multi-billion dollar commercial success. Then, in 1994, Marc Andreesenand Jim Clark formed Netscape Communications Corporation. Their new browser was the most sophisticated yet, was an instant success, and replaced Mosaic almost overnight. In 1995, Bill Gates of Microsoft offered "Internet Explorer" as his company's entry into the Internet competition and the race for web dominance commenced. No one knows the ultimate winner of this corporate battle -- many feel that both will win -- but the stakes are huge.

Today, the number of computer hosts (web sites) exceeds 10 million and is growing at a fantastic rate. Statistics on the web become obsolete the moment they are published; as of September 1996, the web was growing at the rate of 2,000,000 new web pages per month, web sites existed in 150 countries, and almost 300,000 commercial entities had accessible web home pages. Today, there are probably almost 100 million addressable web pages on the Internet, with no end in sight. If the number of web pages doubles every year -- and it is growing faster than that -- then every person over six years of age in the United States will have his or her own web page by the year 2001.

How does the Internet Work?

The Internet is a way for computers to talk to computers. When people log onto the Internet, probably using a browser like Netscape Navigator or Microsoft Internet Explorer, they specify a specific address (e.g. "http://www.cpec.ca.gov"). That address, which is much like a telephone number, prompts the computer to send a signal through a modem or other switching system over telephone lines to other computers at an Internet Service Provider (ISP), which then routes the signal to the computers of a Network Service Provider (NSP), which then locates the address that the individual specified. At that point, two computers can talk to each other and exchange information. It is very much like making a telephone call, but with vastly greater capabilities, since the Internet involves not just voice but print, graphics, animation, links to other sites (hypertext), and almost anything that can be presented visually.

Who pays for the Internet?

Payment for Internet services is made in various ways. In order to gain access to the system, people may pay a monthly rate to an ISP which, in turn makes payments to the NSP -- the entity that maintains the computers that make the system function. Others may subscribe to an online service such as America Online or the Microsoft Network, which then pays the bills to the NSP. While all this is occurring, the local telephone company collects revenues for the time its customers are using the phone lines. In most urban areas, this is a flat rate; in outlying areas there will probably be toll charges.

Why is the Internet a Commercial Success?

The Internet is a commercial success primarily because of its graphical capabilities. This ability to transmit pictures makes advertising possible, and the Internet is increasingly filled with it, not unlike the yellow pages' metaphor noted above. Further, many services that are advertised on the Internet require a subscription, such as to some periodicals, newspapers, stock market research, and a galaxy of otherkinds of information. Increasingly, in the Information Age, people are realizing an old truth -- knowledge is power -- and they are willing to pay for certain kinds of information that may be useful in their lives.

Will the Internet also be an Educational Success?

It already is in a number of ways. It provides a window to the world, and to the world's fund of knowledge and information. As more and more libraries and other information databases go on the Internet, as transmission capacity (bandwidth: see below) increases, and as programming becomes more sophisticated, it is probable that entire courses will be offered directly on the Internet (some already are by such institutions as the University of Phoenix) where they can be accessed from almost anywhere. And even if this practice does not become widespread, it is certain that the Internet will remain an unparalleled information resource to the academic community for as far into the future as anyone can see.

Does Anyone Own or Regulate the Internet?

No one "owns" the Internet per se. It is a huge array of interconnected computers and telephone lines, including fiberoptic lines in some cases. Various corporations and individuals own the computers -- the "servers," transmitters, and receivers that make the system operate -- but there is no overall ownership.

Regulation by government agencies is almost nonexistent. Nominally, the Internet comes under the jurisdiction of the Federal Communications Commission. However, the regulatory environment is extremely difficult for the FCC, in part because the system transcends national boundaries, in part because most people have not seen the need for regulation, and in part because those areas in which some regulation may be desirable by some (e.g. obscenity and pornography issues) often require adjudication. As a result, it may be fair to state that most regulatory issues that do exist at the present time remain largely unresolved.

What are the Internet's Future Problems?

The Internet's biggest immediate and future problem is probably band width. Band width (see Appendix A) is a measure of the system's capacity to transmit information, and as the system continues to experience rapid growth, there is a potential problem of jammed phone lines and very slow transmission rates. Some have even predicted that the Internet will one day collapse altogether, although most observers seem to feel that this danger has been exaggerated.

Currently, most people use a modem to connect with ISP/NSP providers and then with various computer servers that maintain the web sites. Most commercially available modems currently transmit at 14.4 to 28.8 kilobits per second (Kbps), which means that data, at least in text form, can be transmitted at the rate of about 300 to 600 numbers or words per second. Unfortunately, graphics require vastly more memory capacity, so actual transmission rates tend to be very slow when a web site that contains graphics -- just about all web sites today do -- is involved. The site may contain only a few thousands words, which would suggest that transmission to a 28.8 Kbps modem should take only a few seconds, but whenpictures are added, it can take minutes, and if the phone lines are crowded, it may not get there at all.

Many innovations are in limited use at present, and many more are on the way. The bullet chart below indicates transmission speeds for various modem alternatives:

- Modem: 28.8 Kbps
- ISDN: 64-128 Kbps (2.2 - 4.4 times faster than the modem)
- T-1: 1.54 Mbps (53.5 times faster)
- Cable: (Not yet available) 30 Mbps (~1000 times faster)
- T-3: 44.736 Mbps (1,500 times faster)
- OC3/ATM: 155.5 Mbps (5,400 times faster)
- OC12/ATM: 655 Mbps (22,700 times faster)

All of these faster transmission speeds are currently expensive, but if the future of the Internet follows the history of computing generally, the current high costs will decrease over time. It has been observed that the Internet today is like citizen band radio in the 1970s: full of static, limited range, narrow use, etc. Today cell phones have replaced the CB for any number of reasons, including clearer signals, wide range, etc. In the future, some of the transmission modes listed above will replace the modem, with vastly more pleasing results to the user. Just around the corner is everything from three-dimensional graphics to virtual reality. All of it will require greater capacity and speed in transmission, but there should be little doubt that both will soon be available.

Appendix C California Community Colleges: Examples of Technology and Telecommunications Projects

Consortia or Multiple Campus Arrangements

In California, early consortia were formed to develop the potential that members felt television had for the instructional programs of community colleges. The consortia provided a communications link between the member institutions and other agencies. It was felt that through this communication, the members could most wisely and efficiently use the resources that were available to them. During the late 60's and early 70's the concept of moving instruction beyond the campus was being explored by the community colleges, the California State University System, and the University of California System. With television being so pervasive in society at that time, many felt it was important for community colleges to define their role in the use of the medium for instruction and education.

Consortium for Distance Learning

Historically, the Consortium for Distance Learning began in 1969 when members of 7 community colleges in northern California began meeting to discuss the use of television as a distance learning tool. They began their association by working on joint video projects which aired on local PBS and commercial stations. In 1972 they named themselves the Valley Consortium of Community Colleges. In the mid-seventies, a four-campus regional consortium in the Fresno area joined the Valley Consortium, and in 1988, the Bay Area Television Consortium joined. The name was then changed to the Northern California Telecommunications Consortium to reflect the increasing interest of the members in new and emerging technology. By the end of the eighties, NCTC had become the largest user of PBS/ALS materials in the country. Finally, on July 1, 1995, the name was changed to the Consortium for Distance Learning.

Presently, the Consortium for Distance Learning has 24 full Members with full voting privileges, 5 Associate Members, one Appointed Representative each from the Chancellor's Office, California Community Colleges; The Academic Senate for California Community Colleges: the Faculty Open Learning Association; and the office of the President, University of California. Associate Members can be four-year institutions of higher education, county offices of education, and any other educational organization that has an interest in distance learning and wants to cooperate with community colleges in coordinating mutually beneficial Instructional activities. Student enrollment at CDL member institutions this past year was just under 16,200. CDL serves students and members in northern California. [Southern California is served by INTELECOM Intelligent telecommunications].

Purpose and Structure of the Consortium for Distance Learning

The purpose or goal of the Consortium for Distance Learning is to provide quality learning opportunities and equity of access to higher education for all Northern California students. Each member campus has a designated representative. These representatives constitute the Consortium's Board of Directors whose purpose is to direct the activities of the organization. The Board of Directors is the final decision-making body. Specifically, these Board Members provide the means of participation by campuses in the activities of the Consortium and serve as communication channels for member campuses. Board Members approve and adopt the annual budget, elect an Executive Council, establish policy governing the Executive Council, and consider and act upon the recommendations of the Executive Council. The Board Elects a Vice-President who serves on the Executive Council and is President-Elect for the subsequent two years.

The Executive Council consists of 12 members elected by the Board for a two-year period. The President of the Consortium serves as the Chair of the Executive Council while the retiring President is an ex officio member of the Executive Council for the subsequent two-year period. The Executive Council aids in the administration of the Joint Powers Agreement. In general, in accordance with policies developed by the Board of Directors, the Executive Council is responsible for the development and implementation of administrative policies and procedures to ensure the efficient and effective operation of the consortium. A Treasurer is appointed by the Executive Council to monitor the budgetary process.

Member Colleges - By Campus

American River College; Chabot College; College of Marin; College of San Mateo; Columbia College; Contra Costa College; Cosumnes River College; De Anza College; Evergreen Valley College; Foothill College; Laney College; Mendocino College; Merritt College; Modesto Junior College; Monterey Peninsula; Ohlone College; Sacramento City College; San Joaquin Delta College; Santa Rosa Junior College; Solano Community College; Vista College (PACE); West Hills College; West Valley College; Yuba College.

PBS Affiliations

PBS stations are vital Consortium partners. They are the backbone of one of the most important and current delivery systems. Consortium telecourses are broadcast by KCSM-TV, San Mateo, KRCB-TV, Rhonert Park, and KVIE-TV, Sacramento. CDL contracts with each station for broadcast time specifying number of days, time of day, and length of broadcasts. Consortium students receive courses through direct broadcast from these PBS stations and through dozens of cable systems which relay those broadcast signals into the home. These stations believe support of higher education instruction is one of their essential priorities in providing a broadcast service to their respective communities.

An example of a station's instructional commitment to the community is seen with one of the Consortium's major Public Television partners, KCSM-TV, College of San Mateo, a member of the Consortium for Distance Learning. CDL is fortunatein that KCSM's strategic approach is to promote an expanding identity as a community resource for adult life-long learning. The Station Manager indicates that this niche is important because it meets the mission and goals of the station and differentiates it from other PBS stations in the area. A major component of their mission is to provide distance learning by television to their broadcast community. This just-past year KCSM-TV broadcast over 40 telecourses that member colleges in their broadcast area could offer to students; in the present year, that number will be increased to 50. In addition, KCSM is producing half-hour television programs discussing emerging technologies. Member consortium colleges will use these programs to improve communication and feedback to students at a distance who cannot take traditional classes. KCSM is also producing 30-second spot announcements for each member college for promoting distance learning at their college. And finally, KCSM-TV and CDL are partnering on revising the Consortium-owned telecourse, "Voyage: A Chart book for Career/Life Planning." This revision will have an emphasis on interactivity in order to stimulate and increase learning and comprehension.

Bakersfield College

Bakersfield College, an integral part of the Kern Community College District, has undertaken several initiatives involving technology and telecommunications. Despite budgetary restraints and other barriers, Bakersfield College is managing to implement high technology systems that will provide real benefits to students. The system's main benefits are its ability to enhance a student's learning process and the campus' capacity to individualize education to suit each student's unique needs.

Technology tools, including computers and video servers, will be available on every desktop in the library and will allow students to enjoy multisensory educational experiences on a variety of topics by incorporating full-motion video, audio, traditional book text and other materials into learning modules.

Because the system will be set up on personal computers in the library, students will be able to individualize their educational needs. Students using the system will get help on those learning needs and skills that they need help on and spend less time on those areas that the already know well. Different kinds of media can be used depending on how each student learns best. While some students are visual learners, others are auditory learners or have other learning patterns. Through the use of the technology system, responsiveness to whatever pattern of learning the student naturally possesses can be achieved.

The technology system is intended to enhance learning. The human interface between faculty and students is considered to be extremely important. The technology system is seen by Bakersfield leaders to be a way to expand upon already good faculty members' abilities to reach students, and to do it in a way that is best for individual learning styles.

Bakersfield will also utilize the video servers to create satellite uplinks for distance learning opportunities. The live instruction will allow a student in Bakersfield, who is interested in a course not offered at that college, to link to another college thatdoes offer the course and participate in it via video. Remote cameras are also being installed in Bakersfield classrooms so that their courses can be shared with other colleges that have video servers.

In addition to the technology system briefly described above, Bakersfield College is now working with a few foundations on projects that may eventually cause a transformation in the way community college students learn throughout California. For example, a project that builds on aspect s of the technology system being implemented at the College is being advanced in conjunction with the California Community College Foundation. The partnership is intended to provide summer institutes where faculty from throughout the State's community colleges can go to learn how to produce the multimedia courseware on their own. The plan is to establish a central resource for multi-sensory course materials as they are developed. Through such a repository, the materials can then be distributed for use at any of the community colleges and possibly the public schools.

Bakersfield College is also partnering with the League for Innovation in community Colleges on an initiative called the International Community College. This plan involves providing course work over the Internet so that people can take courses and earn degrees without having to physically visit a campus.

Administrative Applications

The following information reflects the current status of technology currently in use within the California Community Colleges focusing only on administrative applications of technology.

Systemwide telecommunications planning - during the past year the community colleges have developed a plan for systemwide telecommunications infrastructure. This plan has been used to support a BCP (Budget Change Proposal) to the State's executive branch in an effort to establish a base level of telecommunications linkage between community colleges. Further aspects of the plan are to fund some pilot projects to explore and establish costs and benefits of various potential expansions of the network. Central curriculum repository - the Chancellor's Office has financed the design and prototype of a central curriculum repository which will contain comprehensive course data for all community college courses. Such a repository will provide valuable information on students and staff who are transferring from one college to another, and to articulation officers. Its development and implementation is contingent upon funding.

IGETC and CASU GE Certification server - the Chancellor's Office plans to build and operate a server which will receive one or more electronic transcripts for a student, and evaluate the course work listed in the transcript against the IGETC(Intersegmental General Education Transfer Certification) and CASU GE

(General Education) requirements. Preliminary design work has been completed. WWW publication of CCC descriptive data and reports - the Chancellor's Office is in the process of publication of various descriptive reports on a WWW server. WWW publication of systemwide policies and procedures - these will include bothestablished policies and regulations and policies and regulations which are under development in the consultation process.

Student Services Technology Symposium - this symposium was designed to increase the knowledge of college staff and provide guidance in the development of a systemwide strategy to facilitate the infusion of technology into the delivery of student services among the California Community Colleges. A report on the proceedings and recommendations from the symposium is under development. Data development to support analysis of student preparation and student success- various projects are underway to address various accountability and program improvement initiatives.

Electronic transcript transmission - the Chancellor's Office seeks to encourage the implementation of electronic transcript transmission among community colleges and with the universities.

Curriculum management system improvements - the Chancellor's office financed the design and development of improved curriculum management software by the consortium with the largest number of colleges using its student information system. This new software captures all vital information for course history and articulation efforts.

Project ASSIST - the California Community Colleges area component partner in the intersegmental project called ASSIST. (ASSIST is a computerized articulation system that provides prospective community college transfers individualized information about the transferability of courses to four-year institutions as well as applicability of courses to degree and general education requirements.)

Project CAN - the California Community Colleges are an integral partner with the CSU in the development of articulation and an articulation database in the CAN project. (CAN is an intersegmental course numbering system that provides potential community colleges students information about course equivalency at four-year institutions.)

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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 17 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. Six others represent the major segments of postsecondary education in California. Two student members are appointed by the Governor.

As of February 1997, the Commissioners representing the general public are:

Jeff Marston, San Diego; *Chair*
Guillermo Rodriguez, Jr., San Francisco; *Vice Chair*
Mim Andelson, Los Angeles
Henry Der, San Francisco
Lance Izumi, San Francisco
Kyo "Paul" Jhin, Malibu
Bernard Luskin, Encino
Melinda G. Wilson, Torrance
Vacant

Representatives of the segments are:

Kyhl Smeby, Pasadena; appointed by the Governor to represent the Association of Independent California Colleges and Universities;

Philip E. del Campo, LaMesa; appointed by the Board of Governors of the California Community Colleges;

Gerti Thomas, Albany; appointed by the California State Board of Education;

William D. Campbell, Newport Beach; appointed by the Trustees of the California State University;

Frank R. Martinez, San Luis Obispo; appointed by the Council for Private Postsecondary and Vocational Education; and

David S. Lee, Santa Clara; appointed by the Regents of the University of California.

The two student representatives are:

Stephen R. McShane, San Luis Obispo
John E. Stratman, Jr., Orange

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 body to the Legislature and Governor, the Commission does not govern or administer any institutions, nor does it approve, authorize, or accredit any of them. Instead, it performs its specific duties of planning, evaluation, and coordination by cooperating with other State agencies and non-governmental groups that perform those other governing, administrative, and assessment functions.

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 Executive Director Warren Halsey Fox, Ph.D., who is appointed by the Commission.

Further information about the Commission and its publications may be obtained from the Commission offices at 1303 J Street, Suite 500, Sacramento, California 98514-2938; telephone (916) 445-7933.

COMING OF [INFORMATION] AGE IN CALIFORNIA HIGHER EDUCATION

Commission Report 97-1

POSTSECONDARY CALIFORNIA EDUCATION COMMISSION

ONE of a series of reports published by the California Postsecondary Education Commission as part of its planning and coordinating responsibilities. Single copies may be obtained without charge from the Commission at 1303 J Street, Suite 500, Sacramento, California 95814-2938. Recent reports include:

1996

96-1 *California Postsecondary Education Commission Workplan, 1996 Through 2000* (February 1996)

96-2 *Performance Indicators of California Higher Education, 1995: The Second Annual Report to California's Governor, Legislature, and Citizens in Response to Assembly Bill 1808 (Chapter 741, Statutes of 1991)* (February 1996)

96-3 *Changes in College Participation: Promise or Peril? -- Adding the Interstate Dimension: A Report by the California Postsecondary Education Commission Executive Director Warren H. Fox* (February 1996)

96-4 *Progress Report on the Community College Transfer Function: A Report to the Governor and Legislature in Response to Senate Bill 121 (Chapter 1188, Statutes of 1991)* (June 1996)

96-5 *Faculty Salaries at California's Public Universities: A Report to the Governor and Legislature in Response to Senate Concurrent Resolution No. 51 (1965)* (June 1996)

96-6 *Moving Forward: A Preliminary Discussion of Technology and Transformation in California Higher Education* (June 1996)

96-7 *Fiscal Profiles, 1996: The Sixth in a Series of Factbooks About the Financing of California Higher Education* (September 1996)

96-8 *Student Profiles, 1996: The Latest in a Series of Annual Factbooks About Student Participation in California Higher Education* (October 1996)

96-9 *Project ASSIST (Articulation System Stimulating Interinstitutional Student Transfer): Staff Comments on the Final Evaluation Report Prepared by the Carrera Consulting Group* (December 1996)

96-10 *Performance Indicators of California Higher Education, 1996: The Third Annual Report to California's Governor, Legislature, and Citizens in Response to Assembly Bill 1808 (Chapter 741, Statutes of 1991)* (December 1996)

1997

97-1 *Coming of [Information] Age in California Higher Education: A Survey of Technology Initiatives and Policy Issues* (February 1997)

COMING OF [INFORMATION] AGE IN CALIFORNIA HIGHER EDUCATION

Commission Report 97-1

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