

DOCUMENT RESUME

ED 359 921

IR 016 129

AUTHOR Heterick, Robert C., Jr., Ed.
 TITLE Reengineering Teaching and Learning in Higher Education: Sheltered Groves, Camelot, Windmills, and Malls. Professional Paper Series, #10.
 INSTITUTION CAUSE, Boulder, Colo.
 SPONS AGENCY Digital Equipment Corp., Marlboro, MA.
 PUB DATE 93
 NOTE 57p.
 AVAILABLE FROM CAUSE, 4840 Pearl East Circle, Suite 302E, Boulder, CO (\$12 per copy for members; \$24 for others, prepaid).
 PUB TYPE Collected Works - General (020) -- Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC03 Plus Postage.
 DESCRIPTORS Academic Achievement; Community Colleges; Distance Education; Educational Change; *Educational Improvement; Educational Quality; *Educational Technology; Higher Education; *Information Technology; Learning; Research Universities; School Restructuring; Teacher Education; *Teaching Methods; *Technological Advancement; Theory Practice Relationship
 IDENTIFIERS Digital Transmission Systems; *Reform Efforts

ABSTRACT

Changes in digital technology offer significant opportunities to advance the quality of education for students and faculty. Technology can serve as a vehicle to expand the educational reach. Perspectives on changing higher education to fulfill the promise of educational technology are offered in the following papers: (1) "Introduction: Reengineering Teaching and Learning" (Robert C. Heterick, Jr.); (2) "Silicon in the Grove: Computing, Teaching, and Learning in the American Research University" (Richard N. Katz); (3) "Reengineering of Student Learning? A Second Opinion from Camelot" (David L. Smallen); (4) "Community Colleges: Using Information Technologies To Harness Winds of Change" (Ronald Bleed); (5) "Comprehensive Universities Refocusing for the Next Century" (Thomas W. West and Stephen L. Daigle); (6) "Information Technology--Enabling Transformation" (Carol A. Twigg); (7) "A Third Opinion from Camelot" (Thomas F. Moberg); (8) "Growing Our Academic Productivity" (Polley Ann McClure); and (9) "Reengineering or Just Tinkering?" (Don Doucette). A list of 17 resources for additional information is included. (SLD)

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Reengineering Teaching and Learning in Higher Education: Sheltered Groves, Camelot, Windmills, and Malls

edited by Robert C. Heterick, Jr.

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Professional Paper Series, #10

SPONSORSHIP ACKNOWLEDGEMENT

*CAUSE appreciates the generous support of
Digital Equipment Corporation
who funded the publication of this professional paper (see pages 46-47).*

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CAUSE Professional Paper Series #10

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FOREWORD

Higher education institutions are on a collision course with their clients. The reality of the nation's economic problems has washed over colleges and universities in a sobering wave of financial cutbacks. While the worst seems to be behind us, our optimism must be tempered by an extraordinary array of competing demands for public support. As much as politicians voice support for the value of education, other pressing issues like health care, infrastructure, and environmental cleanup may capture what few new dollars are available.

Declining public support, however, has not meant declining demand. An ever-anxious middle class continues to seek higher education as an antidote to falling wages in low-skill jobs. Meanwhile, institutions struggle to meet their current commitments to "quality." Citing a long tradition, a structure built around bricks and mortar and a labor-intensive production process, institutions face what on the surface appears to be a difficult choice: Cut access or lower quality.

It is an artificial choice, however. "Doing less with less" is a prescription for irrelevance. If higher education adopts this strategy, it will end the decade a smaller and less socially relevant institution. Our clients—whether they be students or employers or taxpayers—will voice their anger in destructive ways.

Like the corporate sector, our only responsible alternative is to "do more with less" by restructuring our enterprise. This means rethinking our assumptions about delivery systems, curriculum, organizational structures, and the mix of technology and personnel. It means virtually turning the enterprise on its head to find a better, cheaper, more effective way to deliver education, service, and research products.

Technology continues to hold the key to much of this transformation. We long for the equivalent of the "automatic teller machine" in higher education—a cheaper, better, and more reliable delivery system. We do not need learning technology to be as good as current classroom instruction, but far better. However, we do not need technology which adds to our financial dilemma. Unfortunately, much of what we have done to date has added to our problems—expanding our reach certainly, but increasing our costs. The productivity challenge of the next decade and beyond will be to expand access while downsizing both the number of personnel and the configuration of the physical plant.

The challenge will also be to make a direct impact on student learning. This means transforming the role of faculty from "sage on the stage" to facilitator of a learner-centered, technology-based educational process.

The ideal of "anytime, anyplace" education also suggests a dramatic new conception of the college campus. If education can take place in the residence hall, the off-campus apartment, the home, or the workplace, it requires significantly different kinds of capital investment. In the process we will also, no doubt, transform our governance structures, our assessment tools, and our relationships with clients.

Organizations like CAUSE, whose members are the experts in information and computing technology, will find themselves thrust into the center of the higher education restructuring movement. Those of us in the public policy arena who are searching for ways out of our dilemma await your revolution.

James R. Mingle
Executive Director
State Higher Education Executive Officers

PREFACE

Although change is inevitable, it is always accompanied by uncertainty. The advent of changes in digital technology offers significant opportunities to advance the quality of the educational experience for students and faculty. Technology will never replace those qualities of commitment, intelligence, and integrity that are central to maintaining the vitality of the university. However, it can serve as a vehicle to expand our reach.¹

It isn't clear what Aristotle would have done to "reengineer" his teaching process had he access to today's digital technologies, but it might well have been something along the lines discussed by my colleagues in the essays that follow.

A voice from the sheltered groves of the research university, *Richard Katz* tells us that the entrepreneurship characteristic of sponsored research and the German research university model makes bold institutional reengineering efforts difficult. He surmises that while research universities' investments in the information technology infrastructure will create the context for reengineering teaching and learning, major progress will be paced by the faculty reward system and by efforts to achieve a new equilibrium between research, instruction, and service.

We have a view from a liberal arts institution that suggests that their version of Camelot is one that should be tampered with only with great care and at significant risk. Drawing on his experiences at Hamilton College, *David Smullen* observes that liberal arts institutions have worked to maintain the residential nature of the student body and small class size that have been the hallmark of lecture and credit-for-contact—change should be attempted on the effectiveness dimension only.

A community college view expressed here is that the winds of change have already been harnessed by the windmills of two-year schools. Many of the teaching/learning issues that are new to other institutions have already been addressed by many community colleges in their continuing efforts to efficiently cope with a heterogeneous, non-resident student body. *Ronald Bleed* argues that with what has always been their primary, if not singular, focus on learning, many of the lessons of reengineering learned by institutions such as the Maricopa Community Colleges are valuable for study by other institutional types.

The significant impact of state budget-cutting on comprehensive institutions has engendered something near crisis, especially in statewide systems such as the California State University. *Tom West* and *Steve Daigle* draw on their experiences at CSU to suggest that survival of urban and suburban "mall" institutions may depend, in large extent, on changing the teaching/learning paradigm, focusing on changing the institution along the efficiency dimension.

As with any open discussion, there are more than a few views of the "appropriate" course of action. Having completed the essays that comprise the main body of this paper, we shared them with several other practitioners who have been active in the field and solicited their comments.

In her commentary, *Carol Twigg* takes the authors to task for ignoring the fiscal realities of our current condition. She points out the importance of making a clear case that the benefits of technology will outweigh the costs.

Thomas Moberg offers several examples of how information technology is changing teaching and learning in the liberal arts college, based on his experience as both a faculty member and an administrator at liberal arts colleges. He strikes an optimistic note regarding the opportunities for improving the quality of the learning experience.

For her part, *Polley McClure* thinks many of our efforts to "reengineer" teaching and learning will meet with limited success because instruction is the personal creative work of an individual teacher. In many ways, she says, higher education already has achieved the status of an empowered workforce in a "flat" organization.

And, finally, *Don Doucette* makes the clear distinction between doing things differently and doing different things, arguing that just "tinkering" with the current paradigm is insufficient for the task that lies ahead of us.

Given the heterogeneity and diversity in our system of higher education, we shouldn't be surprised that there are many views of how reengineering should be pursued. Given the highly differentiated mission statements of our various institutional types, anything less would be a disservice to the society they serve.

Robert C. Heterick, Jr.
February 1993

¹ *Report of the University Task Force on the Impact of Digital Technology in the Classroom Environment* (Blacksburg, Va.: Virginia Tech., 1989).

1

Introduction: Reengineering Teaching and Learning

by Robert C. Heterick, Jr.

At least since Aristotle's peripatetic garden discourse with his students, lecture has been the principal delivery mode for instruction.

The overwhelmingly dominant model of instruction in American university education, especially at the undergraduate level, is credit-for-contact. In this model, the student's progress and the faculty member's instructional contribution are measured by hours of contact in lecture hall, seminar room, or laboratory.¹

Perhaps for the first time since Aristotle, certainly for the first time since Gutenberg's invention of movable type, we have the opportunity and the technology that will permit us to break with the credit-for-contact model and consider alternatives to lecture as a delivery mode. There are those who subscribe to the Mario Andretti school of change, "If everything is under control, you are going too slow." For them, the occasion of the emerging digital technology is reason enough to change. A more moderate course of action follows the first law of wing walking, "Never let go of what you have hold of, until you have hold of something else." Such moderates will ask for something more than anecdotal evidence that a dramatic shift to digital technology will significantly improve either the efficiency or the effectiveness of teaching and learning. And finally, there are those who follow the first law of engineering, "If it ain't broke, don't fix it." For the educational conservatives it will first be necessary to demonstrate that some, or all, of our current approach is, in fact, broken.

Is it broken?

Institutions of higher education are extraordinarily labor intensive. For many of our institutions, 80 percent or more of the operations budget is allocated to personal services. For at least a decade, the cost of personal services has been rising

at about 8 percent per year and the increase in faculty salaries has consistently outpaced the Consumer Price Index. The consequence has been tuition increases that have about doubled the rise in the CPI. The current recession has further exacerbated this trend with double digit tuition increases promising to double tuition costs between 1990 and 1997 at many public institutions.

Slowly and insidiously student-teacher ratios have been creeping upward. Perhaps more disturbing, we have done little to ensure that the instruction in larger sections has been appropriately supported with a classroom technological infrastructure. Faculty frequently lecture to classes of sixty or more students without the aid of a microphone, much less appropriate projected graphics and course materials designed for optimum impact in large lecture halls. As more institutions chase the research university model we witness a slow, but steady, erosion in the average contact hours of faculty. At the same time, the demographics of our students have changed dramatically. Fewer than half the learners in higher education are the traditional 18-to-22-year-olds domiciled on or near a residential campus. Increasingly, our students will be unable to be either place bound or time constrained as assumed in the credit-for-contact model.

Under the lecture mode/credit-for-contact model, to simultaneously contend with the expected infusion of new students into our system of higher education and reduce average class sizes would require a doubling of our faculties and an expenditure on facilities that is at least as large as our current deferred maintenance deficiency. Simple solutions

¹Report of the University Task Force on the Impact of Digital Technology in the Classroom Environment (Blacksburg, Va.: Virginia Tech, 1989), p. 4. This document is also available to CAUSE members through the CAUSE Exchange Library as CSD-0679.

such as these are not available without massive increases in budgets. Nothing in our current economic situation suggests that such massive increases in capital and operating budgets are possible. Given the changing student demographics, such approaches ignore the educational problems of the majority of our students.

We hear equally simple solutions proffered from the obverse side of the coin. Why not have faculty assume a larger teaching load? While this doesn't address the shortfall in appropriate classroom space, would it at least deal with the shortfall of faculty? The difficulty comes, of course, in the linkage of lecture/credit-for-contact with perceptions of quality of teaching and learning, thereby creating an explicit tradeoff between efficiency and effectiveness. Particularly in the sciences and professions, there is good reason to believe that the effectiveness of instruction could suffer noticeably under the current paradigm.

What we need to do is avoid defining the problem so narrowly as "having smaller sections" or "increasing faculty contact hours," and deal with the real and historic problem—improving both the efficiency and effectiveness of teaching and learning. Our discourse must not presume the lecture mode or the credit-for-contact model. We need also to realize that there are trade-offs implicit in choosing efficiency and effectiveness in any learning model. Looked at another way, the problem might be stated as providing the most effective learning, most efficiently delivered, consistent with the budgets we are likely to receive.

In this broader context we open all sorts of avenues that are not normally part of the discourse surrounding teaching and learning. Large sections are not necessarily bad. Learning can take place without lecture—in fact, without the direct participation of faculty—and learning (teaching for that matter) need not be confined to a campus classroom but could happen in a residence hall, in the office, at home, or even in a high school classroom. We should be encouraged to design learning environments that are most effective for the learner (not all learners necessarily respond best to a given delivery or reception mode), that provide sufficient efficiencies to permit us to operate within our budget constraints.

Is there something else to grab hold of?

Programmed Instruction, Computer Aided Instruction, and Computer Managed Instruction were all supposed to revolutionize teaching and learning in higher education. We have had so many panaceas thrown at us over the last 20 years that it seems only reasonable to ask, what's new? For one thing, the cost of digital technology at the chip level has been decreasing at better than 25 percent per year for the last decade. The cost of an entry level personal computer (in

terms of tuition) is about the same as the cost of a slide rule 25 years ago. We thought little about the requirement of a slide rule then and we should think as little about the requirement of a personal computer now. The operative question should be, "What are the likely capabilities of an entry level computer during the next five years and how can we utilize it to improve learning?"

Today's entry level machine (less than \$1,000) is capable of displaying graphics, some jerky video or animation sequences, and high quality sound, and can be connected to a local area network and through that to the world Internet.

Sophisticated text processing, draw and paint programs, mathematical routines, and a host of non-trivial applications are available at prices comparable to text books. If the five-year future is anything like the five-year past, then 1997 entry level machines will be portable RISC machines with all the characteristics of today's Sun or NeXT workstations—perhaps more. Such machines will clearly be affordable and incredibly powerful.

All that seems lacking is a rich and robust set of applications to complement curricular decisions. The time and effort required to build one of these applications for a whole course is roughly equivalent to that of producing a new text book. The list of new text books coming to the marketplace each month is long and varied. The set of new computer-based applications and alternative learning resources coming to the market could be equally long and varied—if there existed a set of incentives commensurate with those for producing text books.

Access to the campus network, to broadcast and switched video, and to the Internet opens the door to a rich set of new possibilities. It is easy to imagine contact between students and faculty that is neither place nor time bound. In fact, it is already happening. Contact between libraries—not just the campus library—and students is similarly freed from time and place constraints. There is nothing in our technology forecasts that suggests that we are technologically constrained from reaching the holy grail of scholarship—anything, anytime, anywhere.

Are we going too slow?

Is getting on the technology bandwagon like surfing? If we miss this wave will there be another one along in a few minutes? For our research institutions, which are the seed bed for most faculty in higher education, the question of timing is all important. Of all the types of institutions of higher education, research institutions would seem to be the best positioned in terms of technology infrastructure, budget strength, and reward for innovation, to begin the experiments necessary to define the shape of a reengineered teaching and learning paradigm.

There is nothing in our technology forecasts that suggests that we are technologically constrained from reaching the holy grail of scholarship—anything, anytime, anywhere.

Unfortunately, militating against aggressively experimenting with teaching and learning is an incentive system developed with the research university model. Scholarly production, the basis for tenure and promotion decisions, has seldom been defined so as to include improvements to the teaching and learning process. At many research universities, text books are looked upon as second-class scholarly output. A new-found interest in undergraduate education on the part of many research university presidents offers some hope that this situation may change. But, realistically, we have to recognize that measures of scholarly production are not handed down from university administrations but rather are promulgated through the community of scholars. Measures of scholarly production are not institutional standards but are consensus questions across a profession.

An equal contributor to the inertia that dampens experimentation is the lack of appropriate physical surroundings within which experiments may be conducted. Few campuses have classrooms appropriately equipped for "high tech" teaching. Nearly all campuses have concentrated their energies and resources on creating "open laboratories" of personal computers and workstations, forcing students to be constrained by both place and time in their use of that technology. Even our use of broadcast television in distance learning is similarly constrained. The situation is roughly the same as the classrooms of the 1800s where the student had to go to, and queue for, the copy book owned by the school. We have been so taken with the computer *qua* computer that we have lost sight of its potential in creating or augmenting a learning environment.

Learning in ways that do not depend upon delivery by lecture, and/or are not restricted by credit-for-contact, will depend upon the existence of a communications infrastructure. That communications infrastructure must exist at three levels. The campus itself must be wired with megabit delivery to the workspaces in classrooms, offices, and residence halls. Since at most institutions the majority of students reside in the local community, not the residence halls, there needs to be a metropolitan area network that extends the campus infrastructure to students and faculty in the community. And finally, there needs to be a national infrastructure that binds local learners with distant learning resources.

While there is still much to be done, we have nonetheless made significant progress in creating the national infrastructure. NSFNET and the Internet are already delivering on the promise of providing a technological platform for breaking the lecture/credit-for-contact mold. Many institutions, but not nearly enough, have begun the task of megabit delivery to campus workspaces. The capital costs of creating the campus network still seem beyond the reach of too many of our institutions. Even so, it is in the domain of the metropolitan networks that we are farthest behind.

The local telephone companies are aggressively pursuing narrowband Integrated Digital Services Networks (ISDN) in most major metropolitan areas. There is reason to be concerned that this effort will become ubiquitous too late with too little bandwidth. On the applications side we are seeing the development of "freenets" and a number of data services, albeit at very low bandwidth, that offer some connectivity for electronic mail and bulletin boards. What is needed is more aggressive experimentation with higher speed, more pervasive metropolitan networks like those proposed by the Blacksburg Electronic Village experiment.²

Learning is not a spectator sport

Information technology folk are at the center of the maelstrom of change and its accompanying dichotomies. We have, for years, been in the business of providing central services in a business increasingly dominated by niche markets. We have been the purveyors of a homogeneous information service in a technology that is rapidly shifting to customized products. We have been driven by the search for an elusive efficiency in a market that puts increasing emphasis on flexibility. We have been organized to reap economies of scale in a field where economies of scope are currently favored. These dichotomies are a consequence of trying to apply industrial age strategies in the information age. Nowhere are these dichotomies more evident than in our approach to teaching and learning.

If the reengineering and total quality management movements are about anything, they are about offering differentiated services. If we place our focus on the learner we are struck by a multiplicity of cognitive styles. Our digital technologies offer the opportunity to address each learner in a style and at a location with which he or she is most comfortable. The hallmark of our better teaching institutions has been small class sizes—a convenient, lecture-based strategy for offering something approaching an individually differentiated learning environment. The optimum must be something like the learner and Aristotle on a park bench. However, budget constraints have been the proximate cause of a creeping inflation in class size. Unfortunately, lecture as a delivery mode and credit-for-contact as a teaching model do not scale well.

The plethora of digital technologies offers the opportunity to break the industrial age model of teaching and learning and offer a customized service directly to the

If the reengineering and total quality management movements are about anything, they are about offering differentiated services.

²The Blacksburg Electronic Village is a community-wide laboratory for the development of an electronic communications network that will allow businesses, town residents, students, and teachers to communicate through a high-bandwidth information network.

learner. Our institutions of higher education have been amazingly resilient in resisting change. Fortunately, many of our academic administrators are coming to recognize that the system is either broken or soon will be. It still remains for them to devise reward structures that will encourage faculty to experiment with the new technologies to find extensions to, or substitutes for, lecture and credit-for-contact.³ The challenge is not to substitute one model for another, but to find many ways for learning to take place without compromising quality. We need to avoid trying to manage the faculty and concentrate instead on managing the environment so that faculty are encouraged to experiment as broadly with teaching and learning as they do with research.

Our institutions devoted to undergraduate teaching—the liberal arts college, the community college, and the comprehensive university—may prove to be the breeding ground for the most fertile experimentation with the new technologies. For them to do so, they must populate their campuses with the technology and overcome fascination with the computer *qua* computer. Ada Augusta, Countess of Lovelace, a collaborator with Babbage on the Analytical Engine, said it well over a century ago:

In considering any new subject there is frequently a tendency, first to overrate what we find to be interesting or remarkable, and secondly, by sort of a natural reaction, to undervalue the true state of the case.

The true state of the current case is that our digital technologies can be a tremendously liberating force in designing learning venues that bring the full set of senses (sight, sound, action, interactivity, feedback) to the process. If learning is to become a highly differentiated, anywhere, anytime activity it will be necessary to reengineer more than just the syllabus, delivery mode, and teaching model. We will need to make the digital or virtual library a reality as well.

Certainly since the Library of Alexandria, the size of a library's collection has been a reasonable surrogate for the quality of services it offered its patrons. In fact, most industrial age evaluation strategies are focused on similar measures of input. The virtual library requires that *access* supplement and quickly supersede *collection* as the measure of the value of the library to the networked learner. Libraries have been quick to make the transition to automated "back office" services—primarily the online public access catalog. The transition to a rich offering of full text and multi-media has not come as rapidly or as painlessly. Automating the "back office" didn't require a paradigm shift—disintermediating the "front office" (public services) does.

³Ernest L. Boyer, *Scholarship Reconsidered: Priorities of the Professoriate* (Princeton N.J.: The Carnegie Foundation for the Advancement of Teaching, 1991).

The problem of reengineering for libraries is exacerbated by our ambivalence over how best to deal with intellectual property rights in the information age. Information in the networked world is not a commodity—and commodity-based protection schemes for intellectual property don't seem to work well. Librarians are particularly afflicted with the Law of Wing Walking. The proper adjustments to the reward structure to encourage libraries to move vigorously into the virtual library are not obvious and are likely to be difficult to implement once we do discern

them.⁴ But it is abundantly clear that many of the new models of teaching and learning that we will experiment with will be very dependent on new models of library service.

Many of our new education models will feature attenuated contact between the teacher and the student in formal classroom settings. The maintenance of quality will likely require new strategies for examinations and assessment—assessment of both the student and the instruction.

The reduction in the intensity of contact between student and instructor in the classroom will create the need to find ad hoc, unstructured ways in which this contact can take place. While electronic contact between student and teacher will be a valuable new strategy, we will need to re-think the physical layout of the campus and the daily rhythm of activities to encourage the continuing physical contact between teacher and learner. We will need to design faculty/student contact strategies for distant learners who may likely never set foot on campus. The English tutorial system may provide clues as to how this can be accomplished. Just as our definition of a student is changing, we may require similar re-definition of faculty.

In one way, this transformation of university instruction should increase the requirement for faculty contact with students. A university is not just a warehouse of information and technique to be automated with the same eye on a simple "bottom line" as a warehouse of auto parts. A university is a community of scholars. While we can learn much with the aid of books, machines, and other devices, we can understand the life of the mind and the connections between its parts only by sharing that life with others, especially others more experienced or experienced in fields other than our own. A genuine university education thus must include extensive informal and semi-formal personal contact with faculty.⁵

⁴Harlan Cleveland, "Information As A Resource," *Futurist* 16 (December 1982): 36-67.

⁵*Report of the University Task Force on the Impact of Digital Technology in the Classroom Environment*, p. 6.

The assessment of learning is not a new problem, but the infusion of digital technologies into the teaching/learning environment will certainly call for new strategies. There has been an increasing drumbeat these past few years, particularly from state legislatures, for more systematic assessment. The new technologies are likely to make teaching even more of a team effort between course content specialists, delivery experts, and instructional designers. This set of shared responsibilities will make assessment even more difficult. The highly quantitative, input-based assessment methodologies that have been introduced to date seem far too simplistic for this more complex model.⁶ Strategies for measuring outputs, or even agreement on what constitutes appropriate or desirable outputs, are essentially nonexistent and need to be developed.

Learning to live with change

As we move to break the mold of lecture and credit-for-contact, we will be asking our campuses to set aside centuries-old traditions and techniques in favor of experimentation. The experiments are likely to vary significantly among liberal arts colleges, community colleges, research universities, and comprehensive institutions. Between, and perhaps even within, institutions no one model is likely to dominate. The tried and true will coexist with the new and experimental. One person's constraints will be another's opportunities.

⁶See Carol A. Twigg, "Improving Productivity in Higher Education—The Need for a Paradigm Shift," *CAUSE/EFFECT*, Summer 1992.

Some segments of our community will focus on the effectiveness (quality) issues while others will search for efficiency (productivity). Each is likely to be very uncomfortable with the changes that will ensue as a consequence of the infusion of digital technologies into teaching and learning. The part of the educational community interested in effectiveness will focus their attention on developing new course modules while those interested in efficiency will undertake whole courses and radically different teaching/learning strategies. The former will be attempting incremental changes within the current paradigm while the latter will be attempting to reengineer teaching and learning with order of magnitude changes in productivity. Both are needed and both will be useful. These changes will have to take place during a period of significantly attenuated resources, intensely critical public scrutiny, and accelerating technological developments.

Although change is inevitable, it is always accompanied by uncertainty. The advent of changes in digital technology offers significant opportunities to advance the quality of the educational experience for students and faculty. Technology will never replace those qualities of commitment, intelligence, and integrity that are central to maintaining the vitality of the university. However, it can serve as a vehicle to expand our reach.⁷

⁷*Report of the University Task Force on the Impact of Digital Technology on the Classroom Environment*, p. 35.

2

Silicon in the Grove: Computing, Teaching, and Learning in the American Research University

by Richard N. Katz

If the educational context of the small liberal arts college can be likened to Camelot, the 20th century American research university can be referred to as "a sheltered grove in which knowledge is propagated, created, and applied."¹ The variation in content, structure, and emphasis among American colleges and universities is the result of a rich history of American higher education. In his recent study on the priorities of the professoriate, Carnegie Foundation President Ernest Boyer observes that "scholarship in American higher education has moved through three distinct, yet overlapping phases."² These phases correspond with the tri-partite mission of most American universities: teaching, service, and research. Understanding this history contributes to an understanding of the modern American research university, defined here to include Carnegie Research Universities I and II, which issue doctorate degrees and receive annually at least \$12.5 million in federal support.

The American Research University in Historical Perspective

While "Camelot" institutions of higher learning trace their origins to the English and colonial American focus on the student—and in particular on developing students' moral character and leadership qualities—the modern American research university is an educational johnny-come-lately. To understand the American research university, and hence its directions in and approaches to organizing information

technologies in support of teaching and learning, it is first essential to understand their unique origins, academic culture, and reward systems. At least five defining characteristics distinguish the modern American research university from community colleges, liberal arts colleges, and comprehensive universities. While certain of these characteristics will be found among most or all higher education categories, only research universities share all five.

First, even the nomenclature distinctions between colleges and universities are significant. The word "college" has evolved from the Latin *collegium*, the term for society. The earliest colleges were defined in social terms as learning communities in which students lived and to which collectives of scholars traveled. Medieval college teachers were paid through guilds of students. The term "university," introduced in the papal bull of 1243, transformed this notion by adding the corporate dimension. The English, and later colonial American, universities reinforced the corporatization of higher learning by introducing external boards and by seeking public subsidies for their operations. These developments resulted in the "blunting of student economic power" and guarded the institutions' long-term financial interests.³ While the precise historical distinctions between colleges and universities are "not winningly with us,"⁴ they do cast symbolic reflections in the relative emphasis that institutions of those names place on students.

¹Richard C. Atkinson and Donald Tuzin, "Equilibrium in the Research University," *Change*, May/June 1992, p. 23.

²Ernest L. Boyer, *Scholarship Reconsidered: Priorities of the Professoriate* (Princeton N.J.: The Carnegie Foundation for the Advancement of Teaching, 1991), p. 3.

³E. D. Duryea, "Evolution of the University Organization," in James A. Perkins, ed., *The University as an Organization* (New York: McGraw-Hill, 1973), pp. 15-37.

⁴Burton R. Clark, "Faculty Organization and Authority," in Marvin W. Peterson, ed., *Association for the Study of Higher Education Reader on Organization and Governance in Higher Education* (Cinn Press, 1986), p. 267.

Second, research universities—particularly public research universities—embraced early the emergent expansionism, commercialism, and pragmatism of the American mid-19th century by incorporating “practical” instruction into their missions and curricula. Contrast here the emergent American focus on developing “builders” of all kinds—through mechanical arts, business, law, and medical education—with the Jeffersonian ideals manifest in the typical liberal arts college’s mission of preparing students for active citizenship. The Morrill Act of 1862 which created the land grant university and the Hatch Act of 1887, which funded university-based agricultural experiment stations, institutionalized the evolving mission of some American universities to apply knowledge.⁵ In this changing environmental milieu, a new faculty orientation towards applied research was born, defining in another unique way the future American research university.

Third, the issuance of the Ph.D. degree is another distinguishing hallmark of the research university. Commencing at Yale University and spreading quickly to other Ivy League institutions, the issuance of doctoral degrees suggests to historians of higher education the triumph of the German influence on higher education in America. The German university emphasis on scholarly detachment and on research as a university endeavor justified entirely on its own merits took root quickly in America, reaching maturity with the establishment of The Johns Hopkins University in 1878, with its clear emphasis on research and graduate education.⁶

Fourth, the success of federally sponsored, university-managed research efforts in winning World War II, helped Vannevar Bush persuade President Truman that ongoing federal sponsorship of scientific research at American research universities was, again, an end in itself and a source of American leadership in world affairs.⁷ The modern American research university is defined in many ways by the strong influence of continued federal investments in research.

Finally, the war’s end and the passage of the G.I. Bill of Rights heralded a major American higher education policy shift. Overturning centuries of tradition in which the social role of higher education was the preparation of America’s elite gentlemen for enlightened citizenry, commerce, the clergy, or the professions, the G.I. Bill and subsequent financial aid laws provided Americans with broad access to higher education for the first time. These measures and future educational entitlements changed American universities in at least two ways. First, one class of universities, particularly public universities, reorganized to provide mass education for the first time. Between 1955 and 1990, enrollments in

U.S. colleges and universities increased by 400 percent.⁸ The second change wrought by this post-war policy shift was the fundamental change in the racial, ethnic, and gender composition of the American collegiate student body.

Today’s Defining Characteristic—Research

None of the influences described in this short history of American higher education served to shape and mold the research university more than the institutionalization of powerful research incentives posed by the adoption of the German university model and by the post-war federal sponsorship of university research. According to one source, “universities perform almost half of the nation’s basic research [and] about 28 percent of its total research.”⁹

The American research university has been described as “dazzlingly successful.”¹⁰ These approximately 200 research and other doctorate-granting universities garner fully 30 percent of all U.S. higher education enrollments.¹¹ Such success, however, has come at a cost. While many of America’s preeminent research universities compete, according to Clark Kerr, to become tomorrow’s Harvard, Stanford, or Berkeley, the American public appears to be increasingly “disillusioned with research itself...”¹² While the debate over how higher education should or should not balance research incentives with

the need to educate students or to contribute to the community is outside the purview of information technology executives, these executives nonetheless should be aware of the debate and strive to incorporate balanced capabilities in their technology plans, strategies, and investments.

The American research university’s emphasis on research signals at least two important differences to those responsible for supporting the instructional program with information technology. First, implicit to the German re-

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⁸Atkinson and Tuzin, quoting the U.S. Department of Commerce, p. 23.

⁹*In the National Interest: The Federal Government and Research-Intensive Universities*, Ad Hoc Working Group on Research-Intensive Universities (Washington, D.C.: Government Printing Office, 1992), p. 15.

¹⁰Atkinson and Tuzin, p. 22. Also, according to the report *In the National Interest* (ibid., p. 17), the operating revenues of the 170 most “research-intensive” universities rose from \$17.9 billion in 1979 to \$72.8 billion in 1990.

¹¹Ibid., p. 24. See also, for example, Allan Bloom, *The Closing of the American Mind: How Higher Education Has Failed Democracy and Impoverished the Souls of Today’s Students* (New York: Simon & Schuster, 1987).

¹²Clark Kerr, “The New Race to be Harvard or Berkeley or Stanford,” *Change*, May/June 1991, p. 8. See also *Renewing the Promise: Research-Intensive Universities and the Nation*, President’s Council of Advisors on Science and Technology (Washington, D.C.: Government Printing Office, 1992), p. xiv.

⁵Boyer, p. 5.

⁶Ibid., p. 7; see also Atkinson and Tuzin, p. 23.

⁷Vannevar Bush, *Science—The Endless Frontier* (Washington, D.C.: National Science Foundation, reprinted 1980), pp. 10-11.

search university model is the premise that the quality of instruction is directly and positively influenced by the faculty's engagement in research activities. This premise suggests a "trickle down" model of knowledge propagation in which (1) faculty enthusiasm about the process of discovery is exported to the classroom, (2) student learning is enhanced directly by access to research activities and by-products, and (3) curricula devised by active researchers better reflect a discipline's state of the art. The second and more obvious information technology program driver is the set of unique needs posed by a large population of graduate students engaged in original research. The importance of a full-blown graduate program to the planner and provider of academic information technology support cannot be minimized.

As David Smallen points out in this paper (p. 16), one of two "fundamental characteristics" of the ideal learning environment is the presence of "consistent opportunities to interact with other students and the instructor..." While such a proposition is almost axiomatic where applied to undergraduate education and informs the technology planner about the reasonable limits of investments in information technology, it may be significantly less true when applied to graduate education. For example, in a recent study of UCLA graduate student housing preferences, 947 unmarried graduate students were asked to rate the importance of eight academic services and activities in a graduate housing complex. Among this group of students, access to the campus data communications network ranked second only to study rooms in importance. Nearly as important to this group was the existence of group computer laboratories in the housing complex. Perhaps more interestingly, this group of students rated faculty socializing, faculty mentorships, faculty seminars, and live-in faculty as "unimportant" academic activities vis-à-vis their residential needs and experience.¹³

Towards Babel: Campus Computing's First Wave (1947-1977)¹⁴

The unique historical evolution of the American research university has fostered uniqueness in these institutions' information technology strategies, challenges, and approaches. First, the relative emphasis on research, the responsibility for graduate education, and the existence of federal research sponsorship have conspired to strengthen the role of faculty within the framework of academic shared governance. This conspiracy of influences has limited the role to be played by

those with institutional responsibility for the management of campus information technology resources—particularly in the area of instructional computing. So, while research universities should be characterized as "early adopters" of information technology—such as MIT's early acquisition of Whirlwind I—and have invested in large-scale computing since the invention of the first digital computer in 1946, the nature of the technology of this period and the idiosyncrasies of the research university itself have limited the use of computers in direct instructional activities.¹⁵ By 1979, only 6 percent of MIT's \$10 million annual computing expenditures, for example, went directly to education.¹⁶

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In the 1950s and 1960s, America's elite research universities became home to the big machines—those with impressive and even intimidating names such as Whirlwind, Eniac, Maniac, and others. These machines brought automation to many university administra-

tive programs and were made available on a time-sharing basis to students and faculty. Communication limitations, the difficulty of mastering complex programming languages, and not-infrequent frustration with the central campus providers of computing services limited the widespread use of these resources. By 1965, less than 5 percent of the total American college enrollment had access to computing services adequate to meet the defined level of national need.¹⁷

The introduction of smaller-scale computing reduced some of the technical barriers to distributing campus computing power and to diffusing the computer's educational role on campus. Beginning in the late 1960s, faculty—motivated by increasing rewards for research achievement and funded by federal contracts and grants—invested heavily in a wide range of technologies. Many of these investments significantly improved research productivity. Student access to computing during this period improved slowly and, again, more through "trickle down" from research activities than from formal institutional intervention. Institutional and faculty investments during this period were leveraged by matching grants from the NSF which sought to boost the computer literacy of America's future scientists and engineers.

The shift in the locus of campus academic computing to the academic departments and laboratories contributed to the evolution of the research university's patchwork quilt of heterogeneous computing platforms. By the late 1970s, the computing environments of many American research universities could be characterized as dichotomous. On one hand, few of the premier research universities were able to

¹³UCLA Business Enterprises, *Graduate Student Housing Research Project: Marketing Study Results*, unpublished report, October 1991, pp. 120-122.

¹⁴Brian L. Hawkins, "Preparing for the Next Wave of Computing on Campus," *Change*, January/February 1991, p. 24.

¹⁵George A. Champine, *MIT Project Athena: A Model for Distributed Campus Computing* (Boston: Digital Press, 1991), p. 3.

¹⁶*Ibid.*, page 5.

¹⁷President's Science Advisory Committee, *Computers in Higher Education* (Washington D.C.: McGrath Publishing Co., 1967), p. 4.

operate without a large mainframe computer. Large-scale computers were operated to support primarily (1) numerically intensive research, (2) instruction in computer science, and (3) administration. On the other hand, islands of technology emerged in the well-funded, chiefly scientific disciplines.

This dichotomous evolution carried important implications for those with an institutional interest in instructional computing. First, faculty independence in the computer acquisition decision blunted central campus attempts to influence or leverage institutional strategies for instructional computing. Second, the technical heterogeneity of the research university's academic computing environment limited the opportunity for faculty—or their institutions and disciplines—to leverage their own achievements in developing computer-supported course materials. This dependence on often narrowly defined and typically incompatible computing platforms effectively limited the diffusion of courseware, retarded the propagation of new instructional knowledge, and increased the financial and opportunity costs of courseware's adoption by interested faculty. In sum, while research universities have invested early and aggressively in information technology, factors intrinsic to these institutions' missions, rewards, and governance constrained both the leverage opportunities of these investments during this period and the widespread integration of computing into the university curriculum.

Towards Integration: Campus Computing's Second Wave (1979–Present)

The period between the late 1970s and the present has seen the continued exponential growth of computing at American research universities. The trend towards a dichotomous academic computing environment as described above was exacerbated, during this period, by the personalization of computing as manifested in the introduction, in 1981, of the IBM PC. This introduction and the rapid improvements in PC and workstation performance have increased both the power and—more important—the ubiquity of computing resources available to faculty for instructional and other purposes.

Concurrent improvements in software, particularly as regards ease of use, have gone far in increasing the widespread comfort of faculty with computing. This comfort is a precondition to widespread faculty computer literacy which, in turn, preconditions the widespread integration of computing into the academic curriculum.

The increased faculty access to easy-to-use and relatively inexpensive computing technology has made possible a proliferation of computer-based instructional material. Once again, due to funding biases and to differential rates of software development progress towards numerical applica-

tions, much of this development has been led by the physical sciences, mathematics, and engineering. Nevertheless, exciting work in computer-based instruction is emerging across a broad curricular base, including language training, medicine, writing, literary analysis, and the social sciences.¹⁸

If the rapid acceptance and diffusion of personal computers and workstations on research university campuses has empowered faculty to develop courseware, it has also limited the widespread adoption of such courseware by increasing the number of technological islands. So, while one clear theme of the past two decades is the emerging ubiquity of

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computing to the research faculty, another must be the continued challenge faced by campus IT executives of supporting a technologically heterogeneous environment. The academic computing environment of the present research university typically consists of hundreds or thousands of DEC, IBM, SUN, HP, NeXT, Apple, and other

workstations and midrange and mainframe computers with incompatibilities across hardware, operating systems, and applications. Support, training, and the transfer of courseware technology continue to constrain progress in propagating instructional technology.

While the trend towards personalizing computing has increased the complexity of the research university's academic computing environment, other important trends during this period suggest countervailing movements towards integration. Many of these integrating trends are driven by a combination of vision and technological progress.

Networking

Perhaps the most important trend of this nature is the investment in networking. Recognizing the need to maximize the efficiency and effectiveness of historical and prospective investments in information technology, certain leading research universities, such as MIT and Carnegie Mellon University, have articulated unique long term visions for their campuses. The 1978 *Report of MIT's Ad Hoc Committee on Future Computation Needs and Resources* anticipated the dichotomous effects of personal computing and recom-

¹⁸See, for example, John Bernard Henry, M.D., "Computers in Medical Education: Information and Knowledge Management, Understanding and Learning," *Human Pathology* 10 (1990): 988-1022; David J. Unwin and David K. Maguire, "Developing the Effective Use of Information Technology in Teaching and Learning Geography," *Journal of Geography in Higher Education* 1 (1990): 77-82; and M. Dertouzos and W. Burner, *Report of the Ad Hoc Committee on Future Computational Needs and Resources* (Cambridge, Mass.: MIT, 1978).

Other good examples include the University of Michigan's Project Flame (Foreign Language Applications in the Multi-media Environment) and the University of Maryland's Comprehensive Unified Physics Learning Environment (COUPLE).

mended, among other things, the establishment of a campus-wide network. This report predicted for 1989:

Students may very well use their thousand personal machines and other ports to review course material, solve homework problems and submit them, simulate experiments, text edit theses and reports, prepare graphs, perform bibliographical searches, communicate via the campus electronic mail with fellow students or with instructors, or even with students at other institutions, find out what goes on throughout MIT, and check their registration.¹⁹

Projects Athena at MIT and Andrew at CMU demonstrated the research university's ability to leverage information technology through decentralization and networking. Perhaps for the first time, campus IT executives—through their networks—were able to create the incentives for faculty to adopt key technology standards that would increase campus computing integration and mitigate the complexities of a fragmented and diverse computing environment.

Concurrently with the evolution of networks on many research university campuses, the National Science Foundation recognized the ongoing need for supercomputing in support of the American research agenda. By 1986, the NSF established four supercomputer sites whose resources are made available to university researchers on a competitive grant basis or through partnerships with research universities. The NSF supercomputer centers have, themselves, become important instructional facilities. For example, in 1990 alone 102 graduate students and 57 undergraduates from the University of California San Diego made use of the San Diego Supercomputer Center. Undergraduate projects ranged from "modeling of human locomotion" to "computer access for the blind" to "numerical plasma simulation."²⁰

As important (and perhaps more so), the NSF, recognizing the importance of scale in high performance computing, undertook the creation of a national high-speed data communications network to connect its regional supercomputers and provided seed money for regional providers to provide connectivity to many colleges and universities. Significantly, all 200 Carnegie research universities are connected to the Internet—a network of networks—and, thereby, to the NSFNET. Just as the emergence of campus backbone networks has created incentives for faculty to make "connectivity" investments, so has the existence of national networks provided research universities with powerful incentives to invest in the data communications infrastructure. Throughout the 1980s to the present, the prevailing strategic technology theme of research universities has become that of network connectivity.

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Library automation

In addition to the proliferation of personal computers, workstations, and networks, the last two decades have witnessed the emergence of library automation as a major theme of American research universities. The movement towards the online delivery of electronic library resources is of enormous importance to instructional computing because of its focus on text management and delivery, i.e., information access, rather than on data processing. This shift heralds the entry of computing into the learning experiences of the humanists, fine artists, social and life scientists who have not participated in great numbers in the computer revolution.

In the late 1970s and early 1980s, systems like those created by the OCLC and the RLG introduced library computing as a means of economizing and consolidating library cataloging costs and of achieving consistent bibliographic control of a university's library holdings. At the same time, pioneering offerings, such as the University of California's MELVYL® system, established online union catalogues of library holdings and provided public access to new and powerful research tools.

Progress in networking has leveraged the original intent of such tools by extending access to rich sources of bibliographic information in support of teaching and learning. As computing and network capacity grow, many of these catalogues have grown to include other information such as book reviews, indexes, and abstracts. In library automation, the leading research universities are exploring aggressively the opportunities to (1) reduce library costs, (2) improve student access to information, and (3) improve faculty productivity by leveraging library collections through online access to full text. "Access to information—anytime, anywhere" has become another integrating theme of campus computing's second wave.

Information resource management

Related, but not identical to the integrating theme of library automation, is the relatively more current theme of information resource management. As the technical infrastructure becomes increasingly interconnected and, thereby, highly leveraged, the focus of many research universities has expanded to include greater recognition of institutional information as an asset to be managed. Multi-campus projects like CUPID seek to find ways to preserve, store, and distribute textual information electronically, while other projects, like Sequoia, work to develop tools for managing very large datasets. Still other initiatives like those between McCraw-Hill and the University of California San Diego offer the ability to customize textbooks—in real time—to meet the increasingly specific and specialized curricular needs of faculty and students. Still other initiatives such as those sponsored by the Coalition for Networked Information (CNI) seek to create new relationships among librarians, technolo-

¹⁹Champine, p. 5.

²⁰SDSC, "Interactions Between the SDSC and the rest of the UC(SI) campus," updated unpublished report, May 1991.

gists, publishers, scholars, and others to accelerate the flow of published materials across networks.

Economic and sociological trends

Two other trends emerging during this period are conspiring to accelerate the drive towards integration. First, the political and economic context of the American research university is changing. During the 1980s, American research universities sustained tuition increases at rates exceeding inflation. Since 1988, public research universities have witnessed the real economic erosion of support from their states. At the same time, enrollments in many universities have declined owing, in part, to the absolute decline in the supply of Americans aged 18 to 24. The essential theme associated with these facts is that research universities' financial and political capital is at risk, if not on a declining trajectory. Whether cyclical or structural, declining resources suggest the need for institutional strategies that leverage existing resources. New information technologies and strategies that make information, networks, or computers available to students faster or cheaper are likely to prevail over stand-alone solutions and technological islands.

Finally, some of these same pressures, particularly the pressure to maintain enrollments in the face of a demographic "bust," are causing some American research universities to re-think the research priority within their mission. According to former Stanford President Donald Kennedy,

... the overproduction of routine scholarship is one of the most egregious aspects of contemporary academic life; it tends to cancel really important work by its sheer volume, it wastes time and valuable resources, and it is a major contributor to the inflation of academic library costs.²¹

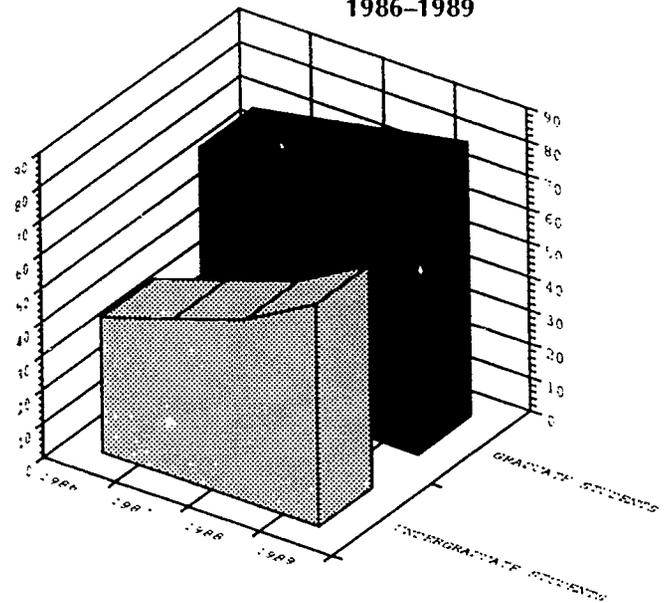
The growing public distrust of research and demand for educational quality is exerting pressure on research universities to recalibrate priorities and to re-focus on undergraduate education. Only as these pressures become translated into formal changes to the assessment process through which faculty are rewarded will step-function improvement in instructional computing become possible. Where in the past computers, then networks, have been in scarce supply, in the decades to come the courseware and faculty time will limit the rate of diffusion of computing in the classroom.

Computing, Teaching, and Learning: Current State, Future Issues and Opportunities

One of the consistent themes reinforced throughout the literature on instructional computing of the 1960s and 1970s is that of access to computing. Owing to the scarcity of computing resources on the campus, budget and technology planners focused the attention of their campus presidents,

²¹Speech by (then) Stanford University President Donald Kennedy, referenced in Atkin and Tuzin, p. 24.

Figure 1
Percent of University of California Students
Using Computers for Instructional Purposes
1986-1989



donors, federal sponsors, and legislators on the need to fund computer acquisitions. Owing to both the considerable success of these planners in securing support and the dramatic improvements in the price/performance of computers during the 1980s, student access to computing per se is no longer the dominant theme at many American research universities. Currently, public and private universities provide one dedicated instructional PC or workstation for each forty-five students. Increasingly important, at research universities, as many as 29 percent of all students own their own computer.²² Certain universities, like Dartmouth, require that students own specially configured computers as a natural extension of classroom experience, while other institutions, like the University of California (UC), support re-seller programs that make computer ownership financially accessible to most students. By 1989, 51 percent of UC graduate students and 42 percent of its undergraduates owned a personal computer. Student ownership of personal computers grew at a compound annual rate in excess of 20 percent in the past five years at this institution.²³

As computing resources have become increasingly commonplace, their use has become nearly ubiquitous. Again at the University of California, nearly 66 percent of undergraduates and 81 percent of graduates reported using computers to support their learning activities. Significantly, graduate students in all disciplines report spending more than three times as many hours in computing-related activities than do

²²University of Southern California, Center for Scholarly Technology, 1990 *EDUCOM/USC Survey of Desktop Computing* (Los Angeles: USC, 1990), p. 1.

²³University of California, 1989 *Survey on the Instructional Use of Technology*, unpublished report, p. 11.

their disciplinary counterparts in the undergraduate program.²⁴

As access to computing has diminished in urgency, access to networks and access to information have risen in importance. Research universities are vesting new importance in their data communication infrastructures in the belief that investment in networks can leverage their own—and others'—computing capacity, library catalogues, data repositories, and scientific instruments, as well as national computing facilities such as the NSF supercomputer centers.²⁵ Another indicator of the emerging priority of networks has been the active role played by research universities in the enactment of the High Performance Computing and Communications Act of 1991.²⁶ This federal law commits, among other things, to a significant expansion of American networking capabilities in support of college- and university-based education and research. Progress towards envisioned gigabit network speeds will increase incentives for research universities to invest in campus networking.

As computing cycles become relatively abundant and accessible at many research universities, and as network connectivity, capacity, and reliability improve and increase, the attention of research universities has enlarged to include concern over the information resources themselves. This new focus responds to a large number of pressures and opportunities, including:

- the growing cost pressures on library acquisitions;
- technological readiness for the distribution of multimedia records, such as images, full-motion video, etc.;
- the growth in size and complexity of national data sources, such as NASA;
- the deterioration of university library collections printed on acidic paper stock;
- new distance learning opportunities made possible by new information technologies.²⁷

The creation of campus computing environments that will realize the full benefits of infrastructure investments in computing, networking, and information resources will be a complex activity. Not only will this activity require substan-

tial and focused campus investment in a broad set of activities, it will require—in many areas—the cooperative involvement of many within higher education and within the publishing, networking, and computer industries.

The strategic emphasis of American research universities on technological integration and on information resources and their management has formed the basis of an emerging and ambitious action agenda for the 1990s and beyond. Convergence on a vision of campus computing characterized by the seamless access to a broad range of information resources—in a variety of media—across diverse technical platforms and institutional boundaries has also informed research universities about the challenges that must be overcome.²⁸ In brief, elements of this emerging agenda include:

- **Continued emphasis on, and investment in, the information technology infrastructure**

The research university vision of computing anticipates not only exponential, but step-function increases in demand for network capacity. Online access to very large datasets—such as census holdings or recordings of particle collisions—will require ongoing investments in the campus's data communications bandwidth. Developments in scientific visualization, online transport of radiological images, digital photography and videography, and online distribution of library holdings as character or image records will inevitably drive ongoing capacity investments and will increase dramatically the demand for network connections. While virtually all research universities support a campus-wide network distribution capability, most have failed to establish or manage the "last mile" connections to every faculty desktop, or key student locations.

It is also likely that the institutional operational definitions of network infrastructure will need to expand to include many of the devices on the network. The fulfillment of the emergent information technology agenda will require that a minimum workstation configuration be defined that can take full advantage of new network-accessible information media. Due to its emphasis on information access, the next wave of research university computing will likely reach those students and faculty who value text, rather than data, processing. As a result, new funding strategies will have to be devised to ensure equitable access to desktop resources to those members of the campus community who are not the

²⁴Ibid.

²⁵For examples, see Caroline Arms, ed., *Campus Networking Strategies: EDUCOM Strategy Series on Information Technology* (Boston: Digital Press, 1988).

²⁶See U.S. Office of Science and Technology Policy, *Grand Challenges: High Performance Computing and Communications: FY 1992 U.S. Research and Development Program* (Washington, D.C.: Government Printing Office, 1992).

²⁷A helpful list of trends that will influence research university IT strategies in the 1990s can be found in Richard M. Dougherty and Carol Hughes, *Preferred Futures for Libraries: A Summary of Six Workshops with University Provosts and Library Directors* (Mt. View, Calif.: Research Libraries Group, 1991), p. 10.

²⁸Robert C. Heterick, Jr., *A Single System Image: An Information Systems Strategy* (Boulder, Colo.: CAUSE, 1988). See also University of California, *Report of the Committee on Long Range Planning for Academic Support Services*, 1991, unpublished report, and Richard N. Katz and Richard P. West, *Sustaining Excellence in the 21st Century: A Vision and Strategies for College and University Administration* (Boulder, Colo.: CAUSE, 1992), pp. 8-12.

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traditional beneficiaries of sponsored research funding. Similarly, while the growth of student ownership of PCs has risen sharply, the evidence suggests that much of this growth fails to anticipate the importance of networks. Research universities will need to develop strategies for helping students acquire desktop platforms, at reasonable costs, that leverage investments in networks and in information resources.

In addition, there is little evidence to suggest that the long-promised "paperless" environment is within sight. Research universities must thus assume that, in spite of progress towards networked information delivery, a large role will continue to exist for information in print form. They will need to develop and finance institutional print strategies that foster a "print-on-demand" capability campus-wide (and most likely to the home) and that differentiate between tiers of student and faculty printing needs. Initiatives like Project CUPID and UCSD's venture with McGraw-Hill seek to develop a working understanding of networked printing's institutional tier.²⁹

Another infrastructure element that will receive ongoing investment in the name of integrating the instructional computing enterprise is the development and refinement of user interfaces. As network connectivity and capacity rise and networked information resources become increasingly accessible, network operators and computing application developers will be expected to facilitate their use through the deployment of easy-to-use, and probably graphical, user interfaces. Just as libraries without catalogues are of limited use, so will access to information "anytime, anywhere" be limited by inadequate directory services and fragmented interfaces. Whether or not a "one-stop-shopping" computing environment can be created and maintained, access to information resources must be organized to minimize student and faculty training time. Similarly, campus information security strategies will require tuning to achieve a balance between researchers' and students' needs for public access to information, and the equally important imperative to secure the fruits of work in progress.

- **Partnerships and multi-lateral research and development of new technologies**

The vision of the research university's third wave is predicated on progress in key technology areas. Most of this progress will be enabled, or constrained, by progress in adopting multi-lateral standards and conventions. Many of these standards and conventions, in turn, will require unprecedented cooperation among universities and between higher education and the computing, communications, and publishing industries. Significant areas of activity that form this element of the agenda include:

- national and international directory services;
- development and refinement of "navigational" tools such as Gopher and WAIS;
- standards for the compression and decompression of bit-mapped images, video, and others;
- progress in developing host-to-host connectivity through such protocols as Z39.50;
- standardization of graphical and page markup protocols to facilitate network-based "publishing";
- creation of electronic data interchange (EDI) capabilities to enable the eventual accounting and billing for access to information resources and network services.

The multi-lateral organizational obstacles impeding progress towards the achievement of this agenda are far more daunting than the technological ones. Newspaper publishers, technology manufacturers, academic publishers, and voice communication carriers share higher education's vision of information services delivery. Historically, however, competitive advantage to these necessary partners has been defined, in part, by creating de facto or de jure standards for their products or services. The continued fragmentation of the marketplace through the standard setting process carries the risk of, at best, creating new technological islands and, at

worst, creating virtual monopolies among the suppliers or distributors of academic information. Efforts like those pursued by the Coalition for Networked Information to engage segments of these industries on delicate subjects like copyright

will become increasingly essential. The essence of where such investments and efforts can lead—and the source of the expected organizational resistance—is the vision of organizational "boundarylessness" articulated by General Electric CEO Jack Welch.

In addition, continued investment in leading-edge technology such as supercomputing will be required. Tools will be needed to maintain, access, and manage very large datasets so that students can simulate and model the social, natural, and physical universe in more meaningful ways and so that faculty can push the frontiers of knowledge. Visualization tools, in particular, will become increasingly important vehicles for helping students at all levels to learn.

- **Research and development in cognitive sciences and in knowledge diffusion**

The vision and strategies of research universities' information technology providers correctly focus their institutions' attention and resources on (1) infrastructure, (2) information access, (3) information resources, and (4) institutional cooperation and partnerships. This focus will create a rich and easy-to-use environment in which student learning and faculty instruction can be influenced significantly by information technology. However, just as the existence of magnificent libraries does not guarantee their use, neither

... new funding strategies will have to be devised to ensure equitable access to desktop resources ...

²⁹"UC/San Diego Developing Custom Publishing Center," in *Manage IT: The Newsletter for the Management of Information Technology in Higher Education*, Spring 1992, p. 1.

does the achievement of the envisioned networked environment assure that network-based tools, information, and courseware will be deployed fully or successfully in the classroom. Ultimately, research university governance typically vests most curricular authority in the faculty, and it will be the faculty, department chairs, and deans who regulate—by action or inaction—the rate of diffusion of these new technical capabilities to students.

In 1972, the Carnegie Commission on Higher Education predicted that "... by the year 2000, it now appears that a significant proportion of instruction in higher education on campus may be carried on through information technology" ³⁰ Most information technology executives now concede that, in spite of the significant and demonstrable gains in this area, even this somewhat tentative *fin de siècle* forecast will not be realized. As in the first two waves of campus experience with computing, progress towards achieving the promise of the third wave will be constrained by structural impediments, many of which are intrinsic to research university governance.

First, while much is known pedagogically about the nature of learning as it relates to computing,³¹ the literature of this field rarely escapes the confines of education departments or behavioral science disciplines. Higher education's failure to "mainstream" these learnings can be ascribed to research university faculty's disciplinary biases and to the academic reward system which reduces faculty incentives to learn about teaching. As a result, while taxonomies and models of the learning process exist³²—and have been mapped to both discipline-based instruction and to instructional technologies³³—the efforts to leverage this knowledge have been limited to those faculty who find the combination of enthusiasm, time, skills, and resources necessary to develop courseware. In sum, the creation of courseware is, and will be, limited by a combination of (1) uneven faculty pedagogical literacy; (2) uneven faculty computer literacy and preparedness; and (3) faculty rewards that discount the time, effort, and achievement surrounding instructional innovation. New multimedia technologies, for example, which hold so much promise for educating the "Nintendo® generation," may fail to realize their potential in the classroom if faculty are not educated in, or rewarded for, their use.

The constraints described suggest factors limiting the creation and introduction of instructional technologies in the curriculum. Another constraining theme is the lack of coor-

dinative strategies to enhance the diffusion of existing courseware within academic disciplines and across institutions. While award programs, such as those sponsored by EDUCOM, provide both publicity and quality assurance for courseware, we do not yet understand well how instructional technology diffuses, or why. Acquiring such an understanding and developing technology transfer strategies that build on research findings may go far in leveraging the investments made by faculty pioneers.

Finally, American research universities should recognize the need to ensure universal student computer literacy if the instructional benefits of campus information technology investments are to be realized fully. Uneven student preparation in this area has led to student learning results that can be characterized as equivocal, at best.³⁴

Conclusion

In sum, information technology's role in teaching and learning will continue to be one of higher education's dominant themes in the 1990s and beyond. What is emerging is a richly interconnected and highly leveraged network of computing resources, tools, and information resources that will provide students and faculty with unprecedented access across disciplinary, institutional, and national boundaries. Importantly, the evolving national and international network infrastructure will also facilitate access, by students and faculty, to each other and to alternate centers of expertise. While the 1990s will likely witness a continued priority on computational power and sophistication, the real news may be the emergence of new text-handling capabilities that will bring computing's benefits to students of all academic disciplines.

The full realization of the research university's instructional agenda will require significant continued investment in networks and in integrative technologies. Also required will be unprecedented inter-institutional and inter-industry cooperation and partnership. Finally, as research universities organize to develop the tools, networks, information resources, and partnerships necessary to realize the vision described, campus leaders will need to engage the academic enterprise in an evolving dialogue on faculty priorities, incentives, and rewards. In this it would be well for campus leaders to remember that the roots of the research university's "dazzling success" fall not in the maintenance of the status quo; rather, the history of American higher education reveals that ongoing change and organizational renewal are our source of strength and, indeed, our imperative.

³⁰Carnegie Commission on Higher Education, *The Fourth Revolution: Instructional Technology in Higher Education* (Berkeley, Calif.: Carnegie Commission on Higher Education, 1972), p. 1.

³¹See, for example, John F. Rockart and Michael S. Scott Morton, *Computers and the Learning Process in Higher Education* (Berkeley, Calif.: Carnegie Commission on Higher Education, 1975).

³²See, for example, Roger Levien, *The Emerging Technology: Instructional Uses of the Computer in Higher Education* (New York: McGraw-Hill, 1972), p. 354.

³³Rockart and Scott Morton, p. 30.

³⁴Roger E. Whitney and N. Scott, "Microcomputers in the Mathematical Sciences: Effects on Course, Students, and Instructors," *Academic Computing*, March 1990, pp. 14-18; 49-53. The authors conclude: "... we cannot see how universities can afford the resources needed to integrate the computer successfully into the curriculum ... we cannot see how universities can survive without integrating computers into the curriculum."

3

Reengineering of Student Learning? A Second Opinion from Camelot

by David L. Smallen

Recent advances in information technology, coupled with calls for reform in higher education, have led to suggestions that major surgery, or reengineering¹, of the teaching/learning process is in order. While attention has been largely focused on the administrative side of the research university, the reengineering net has been cast widely. A general conclusion reached by reengineering proponents is that our system of higher education requires substantial overhaul to improve the productivity of our faculty, reduce costs, and enhance student learning.² Information technology is seen as the infrastructure upon which the reengineered academy will rest. However, when contemplating surgery it is a common practice to seek a second opinion. This I offer, as one who has been responsible for information technology services for the last 20 years at Hamilton College, where the primary focus has always been teaching and learning.

In the American imagination the four-year liberal arts college has become something of an educational Camelot, a nearly perfect example of the ideal learning environment. ... It is a place where students learn from one another as well as their professors. Discussion-sized classes are taught by professors who devote personal attention and concern to their students, challenging them to reach beyond familiar modes of thinking to achieve genuine intellectual growth. Such institutions do, in fact, exist.³

While this nirvana represents an ever decreasing part of the total higher education scene, enrolling less than 10 percent of all students, it offers insights into the strengths and weaknesses of the traditional methods of instruction, and the potential for the application of information technology to enhance, replace, or alter these methods. In addition, the emphasis on teaching and low student/faculty ratios at such institutions provide an ideal test environment for applications of information technology to the learning process.

My thesis is simple:

The environment at liberal arts colleges like Hamilton is close to the ideal for maximizing student learning. Successful applications of technology to the learning process, at any institution, will be ones that address variances from the ideal learning environment. Technology applied in a manner oblivious to these variances will not improve teaching and learning, and will waste critical institutional resources.

Further, technology applied by poor teachers will be no more effective than administrative information systems that automate a poorly thought out procedure. Change for the sake of change is counterproductive and will alter the very characteristics of the learning environment that attract potential students and enhance student learning. For example, at Hamilton applications of technology which decrease opportunities for interaction between faculty and students would likely be detrimental to Hamilton's competitive position. Given the nature of the small liberal arts college, it is unlikely that there are many opportunities to make student learning more *cost-effective*; rather, targeted applications of information technology can improve the *quality* of learning. Senior administrators at colleges that are looking for information technology to reduce instructional costs are going to be disappointed. Quite the opposite is likely to be true!

¹James I. Penrod and Michael G. Dolence, *Reengineering: A Process for Transforming Higher Education*, CAUSE Professional Paper Series #9 (Boulder, Colo.: CAUSE, 1992).

²David W. Benson, "On Productivity in Higher Education," *Policy Perspectives*, March 1992, Section B, The Pew Higher Education Research Program.

³"Learning Slope," *Policy Perspectives*, November 1991, Section A, The Pew Higher Education Research Program.

Learning in Camelot

Hamilton is a co-educational, residential college located in a beautiful rural setting. All but a few students live on or adjacent to the campus. Students and faculty are accessible. For the most part, first-year students enter Hamilton the same year they graduate from high school. Despite the recent depressed national economy and the substantial cost of a Hamilton education, applications to Hamilton have remained steady, although demands on the financial aid resources of the College have been substantial. There is evidence that the most important attractors for potential students are their perceptions that among the schools they apply to, Hamilton has the "best" and the most highly accessible faculty.

Hamilton's mission is unwavering—preparation of students for active citizenship. This preparation is accomplished through the development of fundamental analytical and communication skills, rather than through training for a particular occupation. A liberal arts education is based upon the premise that the future is, at best, uncertain, and that generalists rather than those with specific training are best prepared to deal with that uncertainty. Further, the liberal arts education is concerned with preparation for a "lifetime" of learning.

The lecture/seminar method of instruction at Hamilton has remained largely unchanged, but there have been recent strains on the system, some innovative application of technology in the classroom, and modest calls for curricular reform. Even in Camelot, attempting to steer a new instructional course is difficult.

Instructional methodology at Hamilton follows a pattern common at other institutions. Classes generally are taught either two or three times per week. Class sizes are small, with over 86 percent of all classes having fewer than twenty-five students. Hamilton eliminated distribution requirements in the late sixties, but has gradually moved back to a system of curricular goals which, together with a strong advising system, function as effective surrogates for requirements.

Faculty must deal with the delicate balancing of teaching, professional activity, and community service, as each is important for promotion and tenure. Bi-annual student evaluations of teaching are an important component of the process of self-improvement. To remain competitive with its peer institutions, Hamilton recently reduced the annual faculty teaching obligation from six to five courses, increased the size of the faculty from 150 to 160, and enhanced its system of professional leaves.

Two fundamental characteristics of an "ideal" learning environment, present in the small liberal arts college, are subject engagement—consistent opportunities for students to actively engage subject matter—and interaction—consistent opportunities for students to interact with other students

and the instructor to test their own ideas and to learn from the ideas of others.

These characteristics can be fostered by a variety of physical and psychological features of the environment in which teaching and learning take place. But there are no guarantees. For example, small class size does not ensure that interaction will take place unless the instructor facilitates it. A faculty member who shows excitement for the content of a course can motivate students to engage that subject matter, but the engagement process may be incomplete unless students understand what engagement means. Reading and understanding (engaging) poetry, for example, is different from reading *Sports Illustrated*.

Instructional methodology is the domain of the faculty, who decide what, when, and how courses are to be taught. Most formal instruction takes place without any significant use of technology in the classroom. The spoken word, interaction between students and the instructor, chalk, and blackboards are still the primary delivery mechanisms for instruction. A variety of audio-visual equipment and computers serve as tools of teaching. This approach is successful since the two characteristics of the ideal

environment are present for most courses. As the recent Harvard Assessment Seminars report concluded, "students' academic performance and satisfaction at college are tied closely to involvement with faculty and other students around substantive work."⁴ The report goes on to talk of the value of "interactive classes" and "interactive relationships" in the student learning process.

Even in Hamilton's very traditional environment there are notable applications of technology to learning, including an EDUCOM/NCRIPAL software award winner. These applications are successful precisely because they enhance subject engagement or interaction among students and faculty. Further, these applications impact a significant number of students, since many of them occur in introductory level courses.

Understanding where change can produce significant improvements in student learning is paramount. Targeted applications of information technology, fostered by an appropriate information technology infrastructure, can make a difference in invigorating and improving the learning process. Be forewarned: applying technology to improve student learning is about quality, not quantity!

Approaches to Improving Student Learning

Information technology can be used to improve student learning if it addresses variances from the ideal learning

⁴Richard J. Light, *Explorations with Students and Faculty about Teaching, Learning, and Student Life*, The Harvard Assessment Seminars, Second Report, 1992.

Understanding where change can produce significant improvements in student learning is paramount.

environment, that is, when it is used to improve interaction and subject engagement. These variances are present, to some degree, at all institutions. Targeting areas of learning in which these variances are large is the most cost-effective way to achieve improvements.

For example, at Hamilton, not all classes are of sufficiently small size to ensure interaction among students and faculty. At some institutions large classes are the norm. At universities with large numbers of distance learners, part-time students, or adjunct faculty, even being on-campus may present difficulties. In many subject areas active engagement of subject matter is problematical regardless of class size. For example, visualizing three-dimensional objects in an advanced mathematics course, or understanding the meaning of a poem in an English course, requires subject matter engagement that goes beyond mere reading.

When students actively participate in class discussions they not only test their understanding of the subject matter of the course, but further develop their communication and analytical skills. Facilitating this interaction and making sure all students participate is largely the responsibility of the instructor. In very small classes, under ten students for example, participation is almost assured since students who enroll understand that participation is expected. In larger classes, it is possible for students to remain relatively passive if the instructor adopts a traditional lecture format. When interaction languishes, information technology can help.

Electronic discussion groups, computer networks, and guided discussion software can all be used to promote interaction among students and the instructor on course-related matters. Such discussion groups enable the student to develop confidence in his or her understanding of subject matter prior to participation in class discussions. Additionally, the instructor can guide the discussion by using suggestions or focused questions. While the interaction initially takes place electronically, rather than face to face, the faculty who have used such techniques have noticed that electronic communication of this type is a precursor to interaction in the classroom setting, ultimately improving student learning.

Most campuses already have the technology in place to use this approach. Even a small network in a public computing facility can suffice. In other institutions, networking technology can be useful in distance learning situations where in-class interaction is not possible for most students.

Helping students to actively engage subject matter is another area in which technology has been applied successfully at most institutions. Numerous examples exist of computer applications that help students to engage subject matter in an active rather than passive manner. These range from simple drill and practice in basic mathematics to complex simulations of chemistry laboratory environments. It can be demonstrated that these applications improve

student learning and retention of subject matter.⁵

However, even when it can be demonstrated that integrating information technology into the educational process does improve student learning, there are hurdles that must be overcome to make that integration a reality.

Inhibitors and Opportunities

There are significant variances among faculty, and institutions, in their willingness to experiment with instructional approaches other than the traditional lecture/seminar format, and to support such efforts. What are some of the environmental factors that account for these variances, and what can administrators do to turn inhibiting factors into opportunities?

Marginal benefits and trade-offs

The ultimate decision about whether to incorporate information technology into the teaching/learning process is made by the faculty member, often implicitly, on the basis of a perceived tradeoff between the marginal increase in student learning (over that achieved by traditional method) and the perceived investment in time to learn to use the technology, integrate it with other course materials, deal with problems related to the technology itself, and choose among available technology alternatives.⁶ When all of this is considered the tradeoff does not seem compelling enough to most faculty. For the most part, the faculty's perception is accurate at Camelot institutions, precisely because the two characteristics of an ideal learning environment are abundantly present. There simply is no overriding reason to make the investment.

Faculty have other obligations. Publication, presentations at professional societies, and community service all compete for the faculty member's time. When these other obligations enter the picture most faculty do not see the value of investing their time in something with small marginal benefits to student learning.

Similar trade-offs should be considered at all institutions. If class sizes are large, or students and faculty are not readily accessible on campus, or interaction is not realistic, then the tradeoff balance will change. Unfortunately, at many institutions where classes are large, research is valued

The ultimate decision ... is made by the faculty member on the basis of a tradeoff between the increase in student learning and the investment in time to incorporate the technology.

⁵An excellent review of these issues can be found in *Computing Strategies in Liberal Art Colleges*, edited by Martin Ringle (Reading, Mass.: Addison-Wesley Publishing Company Inc., 1992) in part four, "The Impact of Computing," which includes "Information Technology in the Liberal Arts Environment: Faculty Development Issues," by Carol Lennox, and "Computers for Teaching and Learning," by Marianne M. Colgrove.

⁶*Ibid.*, see Lennox for an excellent review of these issues.

more highly than teaching. However, even if the motivation is present, administrators must provide the resources to minimize the perceived negative aspects of dealing with a new technology. Institutional leadership, from the chief academic officer, supported by personnel in computer services, must be brought to bear to make it possible for appropriate technology to be integrated into the learning process. There are important ways to direct such resources, not all of them directly related to the technology.

Before a meaningful tradeoff can take place faculty must perceive that the application of the technology will improve student learning. This perception is one that is shaped almost exclusively by discussions with colleagues. Computer services organizations can provide information about applications of technology that have been successful at other institutions, but it is the opinions of colleagues in the same discipline that are most important to faculty. National, discipline-based professional organizations have started to play a role in providing forums for improving learning; now senior administrators at colleges and universities must support and encourage faculty attendance at such meetings.

The impact technology will have on student learning will vary by the environmental setting in which it is used. For example, using software that facilitates and encourages student interaction on subject-related matters will have a greater marginal benefit in a course with a large enrollment than in one that is taught in a seminar format. Software to help students acquire basic skills through drill and practice may be more effective in a self-paced setting than in a traditional lecture format. A software product that is used successfully in a chemistry class of 500 students at a research university may be of marginal benefit in a class of sixteen chemistry students at a small college. The recognition that the marginal benefits of technological applications to student learning are different in different settings is essential to understanding how to make effective use of that technology.

Once the faculty member perceives the application will improve student learning, barriers to implementation must be minimized. Removing or lowering barriers will take financial resources!

One such barrier is the perceived investment the faculty member must make in actually learning to use the technology. "Faculty will not take full advantage of computing technology for any purpose if access to such technology means a trip to another building—away from the office, phone, and work materials."⁷ Providing access to computing in the office environment is essential. It is unrealistic to expect faculty to use computing in connection with instruction if they don't use it in everyday activities.

It is unrealistic to expect faculty to use computing in connection with instruction if they don't use it in everyday activities.

Providing such equipment must be viewed as a long-term investment, similar to providing funds for attending professional meetings. Initially faculty will use computing for personal productivity or research, often doing old things in new ways. Anecdotal evidence from a variety of colleges, supported by my experience at Hamilton, has indicated that providing direct access to computing in a faculty member's office is a precursor to any significant application of computing in the classroom. Faculty must develop a comfort level with any technology before they will apply it in a setting in which they have traditionally been the expert. However, providing access to computing is not sufficient for instructional applications of computing to develop, and has often led to disappointment with massive investments in technology at other colleges. Networking the campus, and providing every faculty member with a computer, doesn't

guarantee computing will be used to improve student learning any more than giving a person a hammer ensures she or he will become a carpenter.

Finally, the physical learning environment—the supporting infrastructure—needs attention to eliminate technological distractions. Such distractions include poorly designed computing facilities, inadequate numbers of computers and/or licensed copies of software, underpowered computing platforms, and lack of projection equipment to support classroom demonstrations.

Infrastructure—the amortization problem

Most institutions of higher education made substantial investments in computing technology in the 1980s. Much of this investment is now in need of replacement, especially if it is to maintain its usefulness for supporting teaching and learning. Instructional software now requires more powerful computing platforms. For example, several instructional software products at Hamilton are built on HyperCard™ foundations. Floppy-disk-based microcomputers with minimal RAM are taxed to their limits running such software. This creates unnecessary difficulties for students and a diversion of attention from subject engagement to computer technicalities.

It has been estimated that to create a modest five-year amortization schedule for instructional computing equipment currently in place at Hamilton will require over \$150,000 per year. And a five-year schedule is constraining for implementing instructional applications of computing given the advances made in software!

Even while institutions invested in computing hardware and software, there was relatively little invested in making classroom environments conducive to the introduction of technology. At most institutions, faculty still have to make special arrangements to have a computer and projection panel set up for use in their classes. Whether computing is used only for demonstration purposes by the instructor, or by

⁷ibid., p. 306.

each student at his or her desk, appropriate classroom environments need to exist. Portable LCD display panels have provided low-cost technology for in-class computer demonstrations, but these panels and the associated computers and overhead projectors/screens must exist in sufficient abundance to make it possible for faculty to easily plan to use them. Spending even 10 minutes (often one-fifth) of available class time "setting up" the technology is unacceptable. More classroom environments have to be "technology ready." Anthony Ralston, professor of computer science and mathematics, commenting on why there were so few computing applications in the classroom setting, noted, "One answer is that most colleges and universities still do not have any classrooms suitable for such instruction."⁸

There is no easy solution to the amortization problem. Financial resources will be necessary at a time when the phrase "no new resources" is on the lips of most college presidents. A major way to minimize the financial impact of creating and maintaining the supporting infrastructure is to control its diversity.

Observing standards, minimizing the number of computing platforms acquired and supported, and selecting a small number of generic software products (word processors, spreadsheets, database managers, communications packages) to use on these platforms will minimize support costs and maximize the useful life of every piece of equipment purchased. Senior administrators must demonstrate leadership to achieve consensus on the need for controlled diversity and assure that funding policies for purchases support that consensus. The days of trying to be everything to everybody are gone!

Infrastructure—peopleware

Colleges and universities collectively invested heavily in their own service sectors during the 1980s. The percentage of institutional operating budgets devoted to institutional and academic support and student services increased substantially during that decade. In a similar manner, computing organizations grew substantially during that period. Now, financial constraints in higher education have created pressures on the service side of the institution. Freezes, and even declines, in staff hiring have adversely affected the academic support organizations on campus. This is particularly true in the information technology sector. Computing organizations are finding that they are barely able to maintain incremental changes in existing environments. Fundamental changes, especially those requiring substantial additional personnel support, are not supportable at current staffing levels.

At Hamilton, the information technology services orga-

nization can only support faculty who want to use technology in connection with student learning. Evangelism in the name of technology is not possible! Providing information about software, helping to arrange for demonstration copies, installing software in public computing facilities, and provid-

ing reasonable infrastructure (i.e., classrooms, networks, equipment) is all that is possible with current staffing levels. Software development and continuing support for discipline-specific software must be the responsibility of the faculty member. Additionally, at most institutions it is a practical reality that computing organizations have all they can do to support those

faculty, staff, and students interested in using computing. It is not an effective use of scarce resources to have the computing staff try to convince faculty to use computing technology to improve student learning. Leadership in this area must come from the faculty and senior academic administrators. As John Kemeny said, "Faculty members are more likely to take advice from colleagues in the same department or a related department than from [computer] professionals."⁹

In general, more tasks formerly performed by the computer services organization must now be transferred to the individual computer user. Developing *self-sufficiency* must become an important objective for every computer user. This must be true for faculty who use computing in their courses. As expensive as hardware and software might seem, ultimately personnel-related costs represent the largest component of the use of technology. Controlling diversity helps to maximize available personnel resources, but encouraging self-sufficiency is going to be the only viable long-term approach to supporting technology. Simply, faculty must become the primary support mechanism for technology used to improve student learning. If computing is actively used in a course, the students must see the faculty member as knowledgeable about it. Of course, hardware repair, software configuration, and network management are tasks still appropriately done by the computer services organization. Training in the use of instructional software and ongoing support for related questions must be something that the faculty member oversees.

Developing self-sufficiency among faculty requires access to training, increased experience, and faculty responsibility for decision-making. Faculty who have access to equipment and training will develop experience and confidence over time. They must then assume responsibility for the decisions that relate to the use of that technology. For example, they must work together with computer services organizations to make sure that students have adequate

Senior administrators must demonstrate leadership to achieve consensus on the need for controlled diversity and assure that funding policies for purchases support that consensus.

⁸Anthony Ralston, "Classroom Computing: The Promise Eludes Us," *EDUTECH Report*, February 1992.

⁹"The Computer and the Campus," an interview with John Kemeny, Videotape from the 1991 EDUCOM Conference.

training and accurate written materials that explain how to use the technology. It is not acceptable to "send students to the computer center to do their assignments," expecting them to stumble along.

Conclusion

Using information technology to improve student learning, contrary to the predictions of some "reengineers," is likely to build on existing strengths and characteristics of the current undergraduate educational environment, rather than to radically change it. Change will come from careful reflection about what aspects of teaching and learning are suboptimal, which applications of technology will lead to substantial improvements in student learning, and investing the necessary resources in these applications.

Lessons from Camelot are that traditional methods of instruction are successful when used in environments conducive to student/faculty interaction and subject engagement, and using technology to create and enhance such environments for the student is likely to be successful. Robert

M. Gavin, Jr., president of Macalester College, has pointed out that

... in the long run we shall see that computing has not changed the liberal arts environment so much as the liberal arts environment has changed computing. While many universities and technical institutions have hastened to modify their curricula and instructional methods to accommodate changes in technology, liberal arts colleges have insisted instead that the technology adapt to an educational approach that has proven effective for the past thousand years.¹⁰

Major instructional surgery using information technology in Camelot, and in many other institutions of higher education, is not warranted—and more likely will lead to failure, disappointment, and ineffective use of scarce institutional resources. This doctor's recommendation is to examine your institution from the perspective of variances from the ideal learning environment—and call me in the morning.

¹⁰Robert M. Gavin, Jr., "The Importance of Computing at Liberal Arts Colleges: A Presidential Perspective," in *Computing Strategies in Liberal Art Colleges*, Martin Ringle, ed. (Reading, Mass.: Addison-Wesley Publishing Company Inc., 1992)

4 Community Colleges: Using Information Technologies to Harness the Winds of Change

by Ronald Bleed

For many decades, the landscape across America has been dotted with the sight of windmills attempting to capture the wind's force and convert it to an energized state to create electricity or to pump water. Similarly, the United States landscape is dotted with community colleges whose information technology agendas are attempting to capture the forces of change swirling around them to energize the mission of the community colleges. Two such forces are the move toward "building communities" and the "quality imperative." What follows is an overview of community colleges today, an explanation of these two major forces, and an analysis of how community colleges are using information technologies to harness the winds of change.

Community College Perspective

Since the first "junior" college was established in Joliet, Illinois, in 1901, the number of junior and community colleges has grown to over 1,200 institutions nationwide, enrolling nearly 50 percent of all the students in higher education in the United States. The egalitarian nature of the community college, epitomized by the open-door policy of admitting any adult wanting to take courses, has been the cornerstone of what is called the "community college movement." While elitist institutions have defined their excellence in terms that are exclusionary, community colleges have sought to define their excellence in the service to many.¹

An open door policy and dedication to the service of many means that community college enrollments are continuing to grow and that more and more services are being demanded. A 1991 lead story in *The Chronicle of Higher Education* predicted that

more and more students will be squeezed out of four year institutions and into community colleges. ... as the enrollment pattern shifts, the quality and scope of instruction at community colleges which are already reeling from demands to provide basic education to underprepared students, will assume growing importance.²

In addition to their mission of providing educational access to the many, community colleges are dedicated to the mission of effective teaching and learning. Community colleges claim that they are the premier teaching institutions of higher education based upon the rationale that they offer smaller class sizes and more qualified teachers who are dedicated to teaching and who are rewarded on that basis. The mission statement of the Maricopa Community Colleges, for example, illustrates this commitment to teaching:

The mission of the Maricopa Community Colleges is to create accessible, effective, and affordable environments for teaching and learning for the people of our communities in order that they may grow personally and become productive citizens in a changing and multicultural world. To accomplish this mission, the services area of the Maricopa Community Col-

¹*Building Communities, A Vision for a New Century*, report of the AACJC's Commission on the Future of Community Colleges (Washington, D.C.: AACJC, 1988), p. 1.

²"Academic Leaders Predict Major Changes for Higher Education in Recession's Wake," *Chronicle of Higher Education*, November 20, 1991, p. 1.

leges are general education, university transfer education, employment preparation, basic skills education, student support services, continued education and community services, and economic development services.³

Building communities

The decades of the 60s and 70s marked dramatic growth rates in the number of community colleges and in the number of community college students. This period also saw the shift from the "junior" college concept, a niche in the vertical ladder of formal education, to a much expanded role of transfer education, operational and vocational training, community services, general education, and corporate training.

Today, an extended definition of community is emerging for community colleges, defining community not only as a region to be served but also as a climate to be created.⁴ As the Commission on the Future of Community Colleges has stated, "The building of community in its broadest and best sense encompasses a concern for the whole, for integration and collaboration, for openness and integrity, for inclusiveness and self-renewal."⁵

Community colleges have long recognized the need to empower the individual and most programs have been built upon educating and training the individual. However, emphasis on individualism can have its downside, causing self-centeredness, divisiveness, and selfishness. In *Habits of the Heart*, Robert Bellah observed,

Since World War II, the traditions of atomistic individualism have grown stronger, while the traditions of the individual in society have grown weaker. The sense of cohesiveness is lost. As never before, the nation needs institutions that recognize not only the dignity of the individual but also the interests of the community.⁶

Community colleges attempt to balance the interests of the individual with the interests of the community.

The Commission on the Future of Community Colleges strongly argues that teaching is at the center of building communities: "Teaching is the heartbeat of the educational enterprise, and when it is successful, energy is pumped into the community, continuously renewing and revitalizing the institution."⁷

³Mission Statement of the Maricopa Community College District, 1987.

⁴*Building Communities*, p. 7.

⁵*Ibid.*

⁶Robert Bellah, *Habits of the Heart* (New York: Harper & Row, 1985), p. 109.

⁷*Building Communities*, pp. 7-8.

Within the concept of "building communities" are six major and interrelated themes:

- *a partnership for learning between students and faculty.* To develop and maintain this partnership, community colleges must recognize the changing demographics of students and must keep their doors open to all students to prevent the fracturing of America, both socially and economically. In addition, the recruitment, renewal, and professional development of high quality faculty is essential to the partnership for learning.
- *a curriculum which is in synch with the community.* This curriculum includes the essential literacy proficiencies, the human heritage, technical and career related competencies for the information age, and lifelong education. The challenge of rapid change to the individual and to the community must be met by the curriculum.
- *quality instruction in the classroom.* New approaches to learning, such as collaborative techniques and the use of technology, should be used along with the reinforcement of existing approaches such as smaller class sizes, rewarded faculty, and active learning processes.
- *the extension of the community beyond the classroom.* A larger vision of the community college is required for this theme to be successful. Extension of the community means that student service activities are joined with curricular activities, and recognition that the community is no longer a small geographic area, but is now the world.
- *connections beyond the community college.* Partnerships with K-12 feeder schools and universities are essential. Alliances with businesses, labor, and economic development agencies should also be cultivated.
- *leadership for a new century.* Building communities requires creative, visionary leaders. Community college presidents and other top administrators must accept this challenge and develop the leadership skills required to guide others into the new century. These leaders must also recognize and commit themselves and their organizations to total quality in their institutions.

Quality imperative

The powerful force of the "quality imperative" is the second major force seen swirling above the community college landscape. The concept of TQM (Total Quality Management) is a popular topic for the renewal of American corporations and that same quality momentum is beginning to influence higher education in America. According to another *Chronicle of Higher Education* article,

Campus administrators have experienced a mindset change as retrenchment has led them to incorporate techniques like strategic planning and total quality

Today, an extended definition of community is emerging for community colleges, defining community not only as a region to be served but also as a climate to be created.

management to increase the efficiency and productivity of employees. ... We will be applying a lot of this to the academic program.⁸

The CEOs of six major companies last year issued an open letter to higher education, in which they asked for a broader participation in what they called "the campaign for change." This is their challenge:

We believe business and academia have shared responsibility to learn, to teach, and to practice total quality management. If the United States expects to improve its global competitive performance, business and academic leaders must close ranks behind an agenda that stresses the importance and value of TQM.⁹

Three objectives that were stressed by the corporate CEOs are to identify core knowledge generic to total quality, to develop a total quality academic research agenda, and to develop faculty understanding and commitment to TQM.¹⁰

What are the key principles of quality management? The United States General Accounting Office has made a definitive study on quality management. They cited several fundamental elements common to all quality management environments:

1. A visionary, committed leadership and a team willing to lead the improvement effort.
2. A redefinition of internal and external customers with the understanding of customer expectations and a commitment to satisfy them.
3. Empowerment of all employees with a spirit of teamwork, innovation, risk-taking, and problem-solving.
4. Use of measurement to assess progress toward meeting objectives.
5. Open communication channels and open corporate culture.
6. Development of a quality education and training program.¹¹

The quality imperative is as important for community colleges as it is for corporate America. The promise of a new way of thinking, planning, and managing may not only help to facilitate the "building communities" agenda but it may also be the paradigm for survival in the next decade.

Paul Elsner, Maricopa Community Colleges Chancellor, takes the total quality management program a step further with this definition of "quantum quality." He says that quantum quality means that an organization has reached the highest state of effectiveness when its functions, its services, its goals, its resources, and its deployment of energy, time,

and effort are aligned complementarily and continually reinforce themselves. He points out that quantum quality has similar characteristics to TQM, but quantum quality takes into account our values and our relationship to broader community needs and values. It has the institutional health, betterment of lives, and a greater function of society as its larger ends.

Information Technology Responses

If the forces of "building communities" and the "quality imperative" are so crucial to the future of community colleges, the question is how can community colleges use information technologies to capture these forces and develop an energized state characterized by effective teaching and learning? What are some of the possibilities? Are information technologies properly positioned to contribute to the success of students in the coming decade?

Information technologies are being used in seven ways to energize community college environments, each of which captures the essence of building communities with quality imperatives: teamwork systems, classroom/laboratory systems, student-centered systems, remote learning systems, school connections/partnership systems, faculty-empowerment systems, and information access/research systems.

Teamwork systems

The value of new learning approaches such as classroom research and collaboration are being explored in community colleges. One advocate of these approaches is Dr. John Seely-Brown, who has defined new paradigms for learning. "Collaborative memory," built upon shared creation of individuals, and "transition memory," built upon access to specialists, are the two key components he describes. Both of these concepts are practiced in community colleges today through the use of electronic communications.¹²

Dramatic results in support of such collaborative learning have been achieved at the Maricopa Community Colleges by the use of one piece of computer software. Electronic Forum is a computer conferencing system designed by Maricopa systems professionals specifically for interaction among students and faculty. New patterns of communication occur because students who are shy or who hesitate to communicate verbally discover a real comfort with this new style of electronic communication. Within the Maricopa Community Colleges, use of Electronic Forum has grown to 20,000 students. The system is heavily used by the English classes to help students learn to write better and by many other disciplines for collaborative writing and general communication.

⁸"Academic Leaders Predict Major Changes," p. A36.

⁹Robinson et al., "An Open Letter: TQM on the Campus," *Harvard Business Review*, November/December, 1991, pp. 94-95.

¹⁰Ibid, p. 95.

¹¹United States General Accounting Office, *Quality Managing Scoping Study*, December 1990.

¹²Melanie Zibit Goldman, "The Classroom—A Virtual Community," presentation at 1991 CAUSE annual conference, December 4, 1992.

Outside of the classroom, electronic communication has also provided a meeting place for students to discuss issues and ideas. In community colleges, where most students are commuters, the electronic medium has been effective in giving the commuting student a forum in which to experience the same kind of discussions that residential students enjoy in dormitories or student unions.

Another example of how information technology can be used for collaborative learning can be seen in the way in which at-risk students are paired with advanced students. As economic developments continue to unfold during the 90s and increasing disruptive pressures occur, the dichotomy in society between the "haves" and the "have nots" will continue to increase. The same division will occur in education and the gap between the privileged and the underprepared student will continue to grow. To overcome this enlarging gap, some faculty at Maricopa have proposed notions about pairing the underprepared student with the technically advanced student on powerful computer workstations. Gene Schmidt, a psychology faculty member at Scottsdale Community College, claims that this pairing would lead to a new means of social engagement for these students. Both groups would ask each other different kinds of questions and add unique strengths to their computer pursuits.

Still another example of using information technology to give students insight into the mode of thinking of others is the way in which community colleges are using electronic communication to internationalize the curriculum. The technology response to globalization is just beginning to emerge with the recent establishment of international networks. Students are beginning to communicate with students in other countries through the use of BITNET or the Internet. Throughout the world, these students are beginning to access libraries and databases at remote locations. The effect of this new form of communication is very beneficial for some community college students. For example, in an English class at Mesa Community College, students were required to prepare their papers electronically and then send them to two international readers to comment on the writing of the student. By doing their assignments in this manner, the students were able to obtain new perspectives and gain new information. Because the document was to be reviewed by international readers, the Mesa students were motivated to achieve far greater results with their writing.

Classroom/laboratory systems

A frequently quoted observation of author Tom Peters is, "What gets measured, gets done." Patricia Cross, a highly regarded expert on community colleges who is on the faculty at Harvard University, has advocated that faculty become researchers for their own classes, using a series of tools and

techniques to examine the quality of their teaching from student interactions. The key principle is that measurement must be done "by" the faculty member rather than "to" the faculty member. Maricopa has developed such a sophisticated computer system that monitors the progress of a student within a course. That measurement of progress is made available in an online form to both the instructor and the student. The system also automates the syllabus, the calendar, testing, and electronic mail.

A 1990 study published by EDUCOM reported that community colleges had a better ratio of public access computers per student (1:45.6) than any other segment of higher education.¹³ These computers are often housed in large multi-discipline labs. While many universities have begun to shift the cost of computing onto the student by requiring their personal purchase, community colleges have maintained concern for the students who

will always need access to public labs because they cannot afford one of their own.

In the future, the emphasis of these labs should shift from using the computer as an object of instruction or a word processing tool to providing instructional delivery of curriculum content. The new equipment will need to have multimedia capability to accommodate the many learning styles of the students. In addition, these labs will be increasingly used to support or provide open-entry/open-exit courses. In this format, the student starts and ends the course upon achieving the competencies required in a time period determined by the student. This format has provided "just-in-time" learning by allowing the student to acquire the knowledge in a condensed time period just before it is needed.

Student-centered systems

Traditionally, student service systems have been designed to provide information to college administrators about students for record-keeping purposes. Today, the need is emerging for student services systems to be better aligned with instructional programs and to provide direct benefit to students.

In community colleges, technology is used to increase student satisfaction. The student services functions of admissions, registration, financial aid, and advisement are greatly supported by computerization. The concept of "one-stop" services using online, computer-based systems originated in community colleges. Convenience and flexibility are required and demanded by today's students.

In community colleges, where most students are commuters, the electronic medium has been effective in giving the commuting student a forum in which to experience the same kind of discussions that residential students enjoy in dormitories or student unions.

¹³Kenneth C. Green and Skip Eastman, "Access to Computing: How Many Computers and Where Do We Put Them?" *EDUCOM Review*, Summer 1991, p. 60.

In response to these student demands, kiosks, CWIS (Campus-Wide Information Systems), and voice response systems have begun to appear on college campuses. They are a forerunner of a new generation of systems that will be centered upon the needs of students.

Remote learning systems

Community colleges have long been the leaders of the distance learning movement using broadcast telecourses, correspondence courses, and courses offered by video and audio cassette. Today, distance learning through interactive digital video holds great promise.

A major dilemma facing two-year colleges is that the curriculum is increasingly becoming a "first-year" program. With budget problems growing, the ability of community colleges to offer lower enrollment, second-year classes will decrease. A potential solution to this problem is to offer these courses at one college and distribute them electronically to other colleges. With two-way interactive video, the instructor and students can hear and see what is happening at all locations. The classroom is electronically extended to colleges which could not have offered those courses to their students otherwise.

Still another exciting technological advancement with implications for the distant learner is the notebook computer. The size of these units is shrinking, along with their cost, making them more practical and more affordable to students. When notebook computers are connected to the technology infrastructure of a college, the learning process for students will be improved.

The concept is that a student could use a notebook computer at college, at home, or at work to periodically "dock" with the college computer network to receive and send communications, to receive instructional material, to access library information, to view information about student progress and student services, and to use the computer as a tool for word processing, spreadsheets, databases, and other functions.

Scottsdale Community College began to experiment with this concept in the fall of 1991. A computer was loaned to an adult student who had returned to college after being laid off from an electronics job. In an informal report to me, he commented:

Having the computer, modem and printer is a fantastic aid to me. Without them, I would have spent much more time away from my family—in computer centers, in libraries, in lines. I estimate that your gift has saved me at least 10 hours per week this semester, not to mention commuting costs and hours of typewriter frustration. ... Having a computer at home has increased my abilities. It's like the difference between horseback travel and jet plane travel.

The significance of this student's experience is that he saved himself 10 hours a week of valuable time by using only a portion of the potential capabilities of the computer. In community colleges, where students have many outside commitments, this time-saving factor has the potential of great success and acceptance.

School connections/partnership systems

In January of 1992, the Maricopa Community Colleges received the prestigious Anderson Medal from the Business and Higher Education Forum. Maricopa received this award because it created the "Think Tank," a partnership within the City of Phoenix joining elementary schools, high schools, the community college system, and business and industry.

Working together, these organizations created several projects to help students stay in school and succeed in graduating. A very visible Think Tank project was the computerized student tracking system used to track high school students enrolled in special programs. A similar system is also being used to track the progress

of minority elementary and high school students involved in a major National Science Foundation program.

The connection of schools by electronic networks helps break the political barriers between organizations, inspires new possibilities, and helps the students.

Faculty empowerment systems

The empowerment of faculty is the cornerstone of any future success in using technology in effective teaching and learning. The most important result of empowering community college faculty with technology is what Maricopa Chancellor Elsner calls "the metaphor for change." When properly introduced into the college community, the new technology becomes a major source of pride for the institution. Faculty see the potential of information technology and become excited about its application to their teaching. Because of the institution's investment in new equipment, the faculty perceive that the college is interested in the future. Faculty are brought together to share their experiences and expertise, resulting in the development of a whole new common ground. All of this leads to a revitalized attitude toward the institution, the students, and teaching and learning.

During the 1980s, many faculty became computer literate and successfully used computers in office automation activities. The issue now is how to raise the faculty to the next plateau above basic computer literacy. If faculty are to use the technology to deliver segments of the curriculum, they will need to have available modern, multimedia technology and participate in intense training efforts.

As object-oriented programming emerges, the old ratios of 40 hours of programming time to produce one hour of classroom material will disappear and be replaced with more cost-effective ratios. Faculty will become directly

The empowerment of faculty is the cornerstone of any future success in using technology in effective teaching and learning.

involved in the creation of the software. The flexibility of community colleges to develop new curricula, the reward structure for community college faculty which emphasizes teaching rather than publication, and the commitment to students held by community colleges should enable them to empower their faculty better than other segments of higher education.

Information access/research systems

In the future, with ever-expanding knowledge databases and the volume of information increasing daily, it will be imperative that students learn how to access vast amounts of information. Technology and libraries are rapidly coming together to provide an easy and effective means of access, raising the prominence of the college library in the teaching and learning process.

Estrella Mountain Community College Center, currently under construction within the Maricopa Community College District, will feature an integrated large-scale library and computer commons as the centerpiece building of the campus. Other libraries within the Maricopa system are also being remodeled to combine computing and library services.

The American Library Association Presidential Committee on Information Literacy has recommended:

We all must reconsider the ways we have organized information institutionally, structured information access, and defined information's role in our lives at home, in the community, and in the workplace. ... The better use of information and related technologies will install a love of learning, a thrill in searching,

a joy in discovering, and teach young and old to know when they have an information need and how to gather, synthesize, analyze, interpret, and evaluate the information around them.¹⁴

Summary

America 2000 calls for the restructuring and revitalization of the nation's educational system. Community colleges cannot ignore the demands that will be placed on them for change. The cross currents of "building communities" and "quality imperative" will require technology responses such as those described here to capture this energy.

The new technology can help create new learning communities which empower students with the ability to learn what will be needed in the future. Technology can create an infrastructure in which students can work individually or collaboratively to gain the understanding needed for success in the 90s and beyond.

This energy can also transform the organization called a community college into one that promotes teamwork, focuses on its students' needs, serves its new vision of community, and is continually evaluating itself so that improvements can be accomplished.

¹⁴American Library Association Presidential Committee on Information Literacy, *Final Report, January 18, 1989* (Chicago: American Library Association, 1989), p. 11.

5

Comprehensive Universities Refocusing for the Next Century

by *Thomas W. West and Stephen L. Daigle*

Several social, political, and technological "sea changes" have taken place in various facets of the global society within the past two decades, especially the last three years. On the surface, these changes appeared suddenly, happened swiftly, and often left chaos in their aftermath. However, upon closer examination, the seeds of change had been planted long before and the roots had been gestating for some time.

In most instances, the chaotic fallout which resulted from these revolutions was caused by two factors. First, the stimuli for the change came from external forces or from groups who were not in a position to predict or plan for a new environment. Second, those within the organization who could make the changes ignored the signals and were unwilling to recognize the magnitude of reform needed to survive. Consequently, there was no articulation of a target environment for the future and there was no strategic planning for transitioning to such an environment.

So far the higher education enterprise has not been subjected to a "sea change" of the magnitude experienced by the likes of the steel and now the automotive industries. Currently, the public is focusing on the K-12 system with calls from all quarters in society for major restructuring of that system. Similar calls still are dim echoes for most of higher education. Yet, once again, the social, political, and technological seeds leading to major overhauls in the higher education enterprise have already been planted. The public comprehensive university is most vulnerable to these external forces because of its significant dependency on state funding and its lack of a clearly defined support constituency. At the same time it is possibly in the best position to make the necessary changes to meet the educational needs of future learners because it has been an evolving institutional type throughout its history.

The initial impetus for the public comprehensive univer-

sity was the democratization of higher education after World War II with many more people of all ages seeking a college education. This movement was fueled by the "Great Society" era of the 1960s and the increased federal and state funding of the institutions and financial aid to individual learners. While new institutions were created during that period—both community colleges and four-year colleges—some existing state and municipal institutions, with special missions in teacher education, engineering, technology, and liberal arts, were reengineered into comprehensive colleges. In most instances, these institutions were brought together under a single statewide governance system.

Other writers in this collection of essays on reengineering teaching and learning have characterized the liberal arts college as a "Camelot" where the learner engages the faculty and fellow students in intimate discourse; the research university as a "sheltered grove" where knowledge is propagated, created, and applied; and the community college as a "windmill" where the changing educational needs of individual learners and the public service needs of agencies in the local community are met with appropriate program offerings.

By contrast, over the past thirty years the comprehensive university has been constantly reengineering itself. Initially the emphasis was on homogenizing the teaching missions of the various colleges which comprised the statewide system. In the 1970s attention turned to becoming universities with attempts to move towards the research mission. Some succeeded, but most have not.

Today, this type of institution might be characterized as the "mall" of higher education where learners stop in and out and have choices from a wide range of academic programs designed to prepare them for the professional and technical workplace or for graduate education.

How can comprehensive universities strategically leverage the uses of information resources and technology to meet both immediate and long-range challenges stemming from projected enrollment growth and increasing fiscal constraints? This essay describes how one major multicampus system of comprehensive universities—The California State University System—is responding to this challenge.

Information Resources and Technology at CSU

Throughout its first quarter century (1960-1985) the management of information resources and technology in the California State University emphasized highly centralized planning and control with a central focus on library and media materials, computing software and equipment, information resources staff, facilities, and funds. In effect, it was a "thing-centered" approach, or a Ptolemaic view of the world in action.

During this period, the functions of planning for and delivery of information resources and technology developed under a number of diverse, separate organizational rubrics, including computing (academic and administrative combined), libraries, media services, and data communications. So long as these functions depended on different technologies, the distinct campus and system-wide organizational structures which guided their development were effective. While these functions were separate and distinct on each of the campuses, within each function there was a high degree of uniformity and/or commonality across all the campuses. Much of the commonality was forced by strong central state regulations and CSU system-wide policies of control and, in some instances, centralized management.

This highly centralized and state-controlled approach to computing and communications development in the CSU continued until 1984. In that year, the CSU finally secured exemption from the state regulations that had control and approval authority over all CSU computing and telecommunications matters.

During this same era, central CSU library strategies and some central library management existed. Major library automation endeavors were launched and managed out of the chancellor's office. While there was not a similar centralized management approach to media services, this function

was always inhibited in its development by the lack of sufficient state funding.

In 1985 CSU gained independence from state rules and regulations which governed the development of technology. It set up its own Information Resources Management (IRM) program. Since then the focus of the CSU IRM program has been on the needs of the individual, as reflected in the program's single goal:

Improve the intellectual productivity of each participant—the students, the faculty, the administrators, and the staff—by the effective integration and use of technology in carrying out the instructional, research, and public service missions of the University.

In essence, the CSU IRM program shifted from a "thing-centered" emphasis to a "person-centered" thrust, or a Copernican view of the world.

The CSU IRM program has emphasized that each campus is to be responsible for planning, developing, implementing and operating its own information and technology environment. Initially, at the system-wide level the new CSU IRM program encompassed only academic computing, administrative systems, and data/

voice communications. Over the years the functions of video communications, library, media services, and instructional technology have been added. At the campus level, the degree of integration varies widely. Some campuses have consolidated the management of most of these functions while other campuses have only improved campus-wide coordination among these functions.

The major objectives during this period were to (1) provide students and faculty access to information technology tools, particularly personal computing; (2) build the intra-campus and inter-campus networking infrastructure to enable the faculty and students to gain access to information and computing resources across the campus, throughout the CSU, and external to the system; and (3) continue in sharing resources among campuses, only now the stimulus for cooperation comes from the campuses and not by mandate from the chancellor's office or the state. Given the scarcity of funding, the CSU campuses have been only modestly successful in achieving these objectives.

The California State University System

The California State University was formed in 1960 as part of the State's three-tier master plan for higher education. The primary mission of the CSU, at its founding and today, is to provide a broad range of undergraduate instructional programs and a limited number of masters level programs to qualified students. In general, the top one-third of the high school graduating class is eligible for undergraduate admission.

The CSU is the largest senior institution of public higher education in the nation. It includes twenty campuses, more than 360,000 students, and approximately 21,000 full- and part-time faculty. The campuses span a geographic distance of nearly 1,000 miles, ranging in size from 5,000 students to more than 35,000. Roughly 9,000 students attend classes at eight off-campus sites. Most students in the system commute or live within a few miles of campus—total residence hall capacity accommodates only about 20,000 students—and in increasing numbers they are older and ethnically and racially more diverse.

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The Future: Strategies for Refocusing at CSU

The evolution of the CSU IRM program has been the direct result of merging the technologies that underpin these various information resources and technology functions of the University. Today, the CSU IRM is focused on enhancing and maintaining the quality of information resources and technology capabilities throughout the CSU. Several short-range initiatives and two major long-range projects have been designed to help refocus the institution.

Short-range initiatives

In April 1990, the Board of Trustees adopted a policy framework for instructional technology and endorsed the pursuit of twenty-one initiatives in *The Student, the Faculty, and the Information Age: The Power of Technology*, a report by the CSU Commission on Instructional Technology.¹ These initiatives have four interrelated foci: (1) infusing the curriculum, (2) strengthening the faculty, (3) engaging the students, and (4) developing the infrastructure.

Infusing the curriculum

Information technology which permits modeling, stimulation, communication, and rapid calculation has begun to transform the theory, content, and practice of growing numbers of academic disciplines. According to the report of the Commission, technology also holds the promise of greater effectiveness in both teaching and learning:

Information technology which permits modeling, stimulation, communication, and rapid calculation has begun to transform the theory, content, and practice of growing numbers of academic disciplines.

The infusion of information technology into the teaching/learning process presents opportunities and challenges. To achieve an appropriate infusion of information technology involves understanding and matching the general states of the learning process, the characteristics of the students, the basic characteristics of the material to be learned, and the information technology methods to be employed in each of the academic program disciplines.

The challenges to proceeding with infusing information technology into the curriculum are many, including:

- finding, adapting, developing, and accepting pertinent applications software and courseware;
- gaining access to fully developed and flexible knowledge bases;

- providing the faculty incentives and rewards for remaining technologically current in their own disciplines and integrating appropriate information technology into their courses and related support services for students;
- seeking modifications to existing federal copyright and intellectual property laws and related CSU policies in order to facilitate making valuable information readily available to the faculty and students; and
- ensuring that students have access to the hardware and techniques that they will need as professionals in their respective academic disciplines.

The Board of Trustees endorsed six initiatives aimed at infusing the curriculum with technology, dealing with the following issues: modification of procedures for reviewing degree programs; integration of information technology into course delivery; faculty incentives and rewards; copyright and intellectual property laws and regulations; expansion of the system-wide academic discipline technology councils; and development mechanisms for CSU technology transfer.

The individual campuses have the lead on the first two initiatives and progress has been slow but steady. Nothing has been done to alter the current faculty rewards system. The CSU is looking to the Coalition for Networked Information² for leadership in dealing with copyright and intellectual property issues, and plans to deal with the technology transfer initiative through its system-wide academic technology discipline councils.

Strengthening the faculty

The Commission's report also identified new faculty needs in the information age that universities must meet:

- ongoing training opportunities to remain technologically current in their academic disciplines;
- personnel support services such as reference librarians, media specialists, instructional systems developers, computing consultants, and equipment technicians to assist them in gaining access to and effectively using information and instructional technology;
- an appropriately configured scholar's workstation located in the faculty office which is linked

¹*The Student, the Faculty, and the Information Age: The Power of Technology*, The California State University Commission on Instructional Technology (Seal Beach, Calif.: The California State University System, 1990). This document is also available to CAUSE members through the CAUSE Exchange Library as CSU0389.

²The Coalition for Networked Information was formed by the Association of Research Libraries, CAUSE, and EDUCOM in March 1990 to promote the creation of and access to information resources in networked environments.

to libraries, shared computing resources, knowledge bases, media centers, and colleagues on campus, across the campus and externally via an integrated network of voice, data, and video;

- educational resources such as computer-mediated software/courseware, printed materials, and knowledge bases;
- resources and policies to encourage faculty to develop software and courseware that will enhance the university's role in using cutting-edge instructional technology; and
- technologically sophisticated classrooms and laboratories that will facilitate teaching and research that supports the teaching mission.

The Board of Trustees endorsed four initiatives in this area. One initiative focused on finding ways to facilitate faculty development in the uses of technology through campus and system-wide activities. The other three initiatives call for revising and updating the budget formulas for faculty desktop technology, library materials (including access to external databases), and media services/instructional development. Lack of special funding has slowed the first initiative and the state's financial crisis, coupled with CSU's proposed revision of the budgeting process, has suspended efforts to implement the others.

Engaging the students

The CSU believes that since today's university students will comprise tomorrow's workforce and productive citizens in society, as learners they must acquire basic knowledge, embed that knowledge, integrate the new facts with their existing concepts, and test the implications of those concepts. The goal is to become well prepared and highly skilled to be intellectually productive in the workforce and informed citizens in the community. Their intellectual productivity should be enhanced upon entering the university. Student needs were determined to include

access to student information technology workstations, located in computing laboratories on campus, at off-campus centers, and at their homes and/or places of work that are linked via networking to the faculty and to the libraries, computing resources, and media centers, and to external knowledge bases that are pertinent and essential to their learning experience.

The Board of Trustees endorsed three initiatives in this area. One initiative calls for the pursuit of state funding of student access to information technology. While there has been little success in securing operating funding, there has been success in getting equipment funding and space via the capital budgets.

A second initiative calls for developing technology-based learning processes. Most of this activity is taking place

at the individual faculty level. Until last year there was special funding for such innovation.

The final initiative calls for each campus to develop a comprehensive technology plan to meet the needs of the students. With varying degrees of integration and success every CSU campus produces an annual information resources and technology plan.

Developing the infrastructure

If technology is to be integral to the university's mission, an appropriate and comprehensive infrastructure must be developed. The Commission proposed that such an infrastructure should consist of:

- an integrated technology environment that links the individual participants (faculty, students, staff, and managers) to the knowledge bases and technology tools they need to be intellectually productive in their respective roles; and
- a coherent management approach to ensure effective planning and efficient utilization of the information technology resources and services.

The Board of Trustees endorsed seven initiatives, dealing with such issues as organization, budgeting models, physical plant standards, and intra-campus, inter-campus, intersegmental, and external networking. Significant progress is being made on each of the initiatives associated with infrastructure. For example, the chancellor's office was reorganized based on the recommendations

in the report; CSU-net has been enhanced substantially since the report was issued; standards for libraries and classroom structures have been established; and efforts are now under way to influence the impending changes in the CSU budgeting system.

Long-range strategies

In November 1991, the CSU chancellor organized the Commission on Learning Resources and Instructional Technology, charging it with developing policy guidelines and a strategic plan in two major areas—distance education and the library and media services. As a consequence, the Commission has launched Project Delta and the Libraries of the Future Project.

Project DELTA

Project DELTA—Direct Electronic Learning Teaching Alternative—is an important new strategy to help meet the projected student enrollment increases over the next two decades in the CSU. The project's goals are to greatly increase the role of technology in educational delivery by expanding existing CSU campus efforts and by promoting

Project Delta—Direct Electronic Learning Teaching Alternative—is an important new strategy to help meet the projected enrollment increases over the next two decades in the CSU.

multi-campus cooperation in technical and programmatic areas.

Like its symbol, Project DELTA is about change. It envisions alternatives to the current way of teaching and learning among the twenty campuses of the CSU system. It builds on the long history and traditions of academe within the context of long-term fiscal challenges and significant enrollment increases projected for the next two decades, and the conditions and opportunities for change which they imply. It suggests that solutions to these issues lie, at least partially, in developing and implementing an effective teaching and learning delivery environment using the learning tools of emerging information technologies.

An important assumption of the project is that the teaching and learning paradigms of the information age may be significantly different from those of previous generations, and that the educational needs of learners and scholars may require major changes in how knowledge is created, stored, transmitted, and acquired. The teaching and learning universe of the information age assumes that boundaries of place and distance become less important as demands of time and access for the individual become more important.

The need for Project DELTA stems from four interrelated sources: individual, institutional, political/social, and technological. Together they form a network of internal and external pressures on the CSU which may challenge many traditional assumptions, policies, and practices concerning the nature of higher education in the next century.

Individual expectations and demands concerning the nature and delivery of educational services are changing, largely in response to technological innovations. Increasingly, institutions of higher education will be expected to offer instructional and support services based on the convenience of consumers rather than that of campus constituencies. Education which is truly learner-centered may be delivered directly to the individual at a time and in a place determined by the learner. Personalized instruction of this nature depends on sophisticated delivery systems and portable learning tools made possible by the revolution in digital electronics.

Institutional pressures include enrollment growth, facility deficits, faculty supply, and fiscal retrenchment. System enrollments are projected to increase by approximately 140,000 to 170,000 students by the year 2005. Current estimates suggest that roughly 50,000 students will have to be accommodated through means other than the existing twenty campuses or academic calendar (i.e., off-campus centers, instructional technology, year-round operation) once current and planned facilities are filled to capacity.

During this same period, fourteen of the existing twenty campuses are projected to reach their physical limits, dictating the need for additional campuses in those areas, or new

modes of service delivery. The facility needs of the system as a whole would require building the equivalent of a 10,000-student campus each year for the next fifteen years. The current five-year Capital Outlay Plan projects an average annual budget of \$405 million, yet funding for capital projects is based on voter approval of bond propositions, which face increasing opposition and uncertainty.

Faculty resources are no more secure. Like all other institutions in the nation, the CSU is in the process of replacing an entire generation of tenure-track faculty. The system is projected to hire almost 12,000 tenure-track faculty over the next twelve years. However, the largest source of new faculty, recent Ph.D. graduates, has not increased in numbers for more than a decade.

Finally, few economic scenarios for public sector institutions are positive, if recent studies are accurate. Given a host of structural obligations (notably, corrections, welfare, and debt service on general obligation bonds), the gap between state revenues and expenditures is projected to grow steadily worse during the 1990s.

These four issues—enrollments, facilities, faculty, and public revenues—individually and collectively are stimulants for a new way of thinking about higher education. Each is a major challenge, requiring responses that are equally profound.

Political/social pressures, too, are reaching new levels. Higher education is one of the few institutions in American society that historically have maintained widespread public confidence. Yet legislative demands for accountability and efficiency dictate exploring all reasonable alternatives for the delivery of higher education services. Feasibility studies and cost-benefit models amount to good political as well as good economic sense. Greater flexibility and convenience in instructional and support service delivery offer means for maintaining public support in a consumer-driven market.

Technological resources include the broad fabric of technological change, economic dislocations, and changes in cultural values and lifestyles. The recent "marriage" of computing and various forms of telecommunications can be expected to increase the scope and pace of technological innovation almost beyond imagination. The revolution in digital electronics is transforming the nature of work in every business and institution. It is unlikely that higher education can stand apart from these currents of change if it plans to be one of the nerve centers of the information age. Emerging multimedia technologies and communications networks can make learning more convenient, efficient, and effective while broadening access far beyond the constraints of time and place.

All of these pressures point to a need for alternatives to traditional academic customs and practices. The very forces that are rendering traditional forms obsolete contain the

... institutions of higher education will be expected to offer instructional and support services based on the convenience of consumers rather than ... campus constituencies.

seeds for workable alternatives. The missing links are a vision of an alternate future and a plan to make it happen. Project DELTA is a proposed response to that challenge.

As stated, Project DELTA is designed to envision and develop alternatives to the dominant approach to teaching and learning in the CSU and, indeed, higher education generally—one that is print and lecture oriented, time restricted, and place bound. Project DELTA will not immediately replace the traditional instructional paradigm, but is designed to enhance it and over time transform it.

Three criteria must underlie the success of the DELTA venture. First, it must sustain the quality of teaching and learning achieved in traditional classroom settings. Second, it must increase the amount and convenience of student access to higher education. Third, it must be cost effective compared to existing delivery methods, thereby promoting greater institutional accountability in the use of public funds.

Project DELTA is an affirmation of the state's and system's historic commitment to higher education as expressed in the *Master Plan for Higher Education*. It assumes that it is unacceptable to educate proportionately fewer citizens than now, and that ways can and must be found to reconcile available resources with enrollment pressures and the economic demands attending lifelong learning. Expanding student access to higher education in California is both an economic necessity and a moral imperative. The future health of the economy requires it, and social equity demands it.

The overall goal, then, of Project DELTA is to develop an alternative and effective learning/teaching strategy to deliver academic courses and degree programs which emphasize direct interaction among learners, faculty, and the relevant information resources using electronic media as the primary delivery mechanism.

The specific objectives of DELTA are to:

- give each existing CSU campus an opportunity to extend its services more pervasively into the communities it serves;
- facilitate inter-campus sharing of program offerings, resources, and services; and
- provide a viable alternative to building additional facilities, including new campuses.

It is the intent of the Commission on Learning Resources and Instructional Technology to draw upon these experiences, talents, and knowledge of the CSU campuses, as well as from other universities, colleges, and private industries and organizations. In fact, the Commission plans to invite private sector partners to join with the CSU in Project DELTA. In addition, experts from CSU campuses, other institutions, and the private sector partners will be asked to serve as temporary staff to accomplish specific planning tasks.³

Libraries of the Future Project

The second major project to be undertaken by the Commission on Learning and Instructional Technology is to develop a new vision and strategy for providing the vital information and learning resources to the students and faculty of the CSU. The goal of this project is to ensure that each CSU learner and faculty member will have access to and be able to retrieve the information and learning resources vital to the learning experience.

Three major trends are compelling the CSU to examine how library services are going to be delivered to meet this goal:

First, the CSU has changed its budget allocation process. In the past, allocations of resources to libraries were derived by formula related to student FTE and based on standards.

The CSU has abandoned the formula/standard approach thus removing the sacred guards of the library budgets.

Second, the vast array of new digital technology and its potential to make knowledge/information resources directly available to students and faculty has significant implications for how an institution organizes to accomplish its goals. A basic question that needs to be ad-

ressed is, "What is the fundamental business of the CSU libraries?"

Finally, the increasing fiscal constraints faced by institutions coupled with the rapid inflation in book and periodical prices have dramatically curtailed the ability of the CSU libraries to serve their clientele.

The Commission on Learning Resources and Instructional Technology has endorsed a plan of action proposed by The Council of Library Directors. The plan calls for the directors to spearhead a year-long strategic planning effort to examine a series of issues and questions within a three-dimensional framework.

One dimension of the framework focuses on the information resources. The issues involve developing strategies for developing the accessibility of knowledge/information on campus and off. In the past the strategy involved developing the campus library collections and augmenting it with interlibrary loans. Such an approach may be characterized as a "just-in-case" strategy. Given the serious financial constraints facing CSU libraries an examination of alternative strategies becomes imperative.

³For details about how Project Delta will be implemented, including a set of tasks to be accomplished over a three-to-five year timeframe, see *Project Delta Planning Phase* (Seal Beach, Calif.: The California State University, 1992). This document is also available to CAUSE members from the CAUSE Exchange Library as (SD)-0678.

The vast array of new digital technology and its potential to make knowledge/information resources directly available to students and faculty has significant implications for how an institution organizes to accomplish its goals.

A second dimension involves dealing with the organization of the campus entities (library, media, computing, and telecommunications) involved in the campus information and technology function and deployment of the personnel. The CSU has always had limited staff resources in this arena and has recently been faced with cutbacks. This project will give attention to alternative ways to share resources within and among campuses.

The final dimension is infrastructure. The project must determine how best to develop the appropriate technology infrastructure on and between campuses. As part of this task the issues of trade-offs between using capital funds for new buildings or developing the technology infrastructure must be addressed.

Conclusion

The CSU recognizes it faces a unique "sea change" in terms of the growth in the number and diversity of students it must

serve by 2005 with limited resources. It also recognizes that the effective uses of information technology in the delivery of instruction and information resource services holds promise for successfully dealing with this impending "sea change." By strategically planning now, the CSU hopes to articulate its own future environment.

The seeds for using technology as a strategic lever have been planted and have been gestating in the CSU over the past three decades. These seeds have not reached full maturation due, in large measure, to lack of resources. However, while there may be significant internal resistance to altering the status quo, social, political, and technological conditions are right to proceed vigorously with refocusing the CSU's teaching/learning environment by developing new approaches which acknowledge that the individual learner is at the center of the educational experience in the information age.

COMMENTARIES

Information Technology— Enabling Transformation

by Carol A. Twigg



Carol A. Twigg is Associate Vice President for Academic Programs and Information Technology at SUNY's Empire State College. She leads the recently created ESC-SUNY Center for Learning and Technology, whose mission is to develop innovative applications of instructional technology. She holds a doctoral degree in English literature from SUNY Buffalo.

When I was asked to write a commentary on the topic of reengineering teaching and learning, I was immediately excited about the prospect of reading and thinking about a variety of perspectives representative of all sectors of American higher education. I was asked specifically to comment on what may be missing in these perspectives. I am a firm believer in the need for change in higher education as a response to both the changing composition of our collective student body and the growing lack of public confidence in the ability of our institutions to serve students in a cost-effective way. While many topics for discussion are suggested by the multiplicity of views presented here, I would like to focus on what I believe is the most important question these papers raise: Who is going to pay for all this, and, more importantly, why should they?

Despite the many differences my colleagues exhibit, differences stemming largely from their individual places in the higher education spectrum, they all agree on one thing: we need to spend more money to buy more stuff.

David Smallen describes the need to remove the barriers that prevent the implementation of technological applications on campus. Smallen's ideas of how to spend money include providing direct access to computing in each faculty member's office; eliminating "technological distractions" such as poorly designed computing facilities, underpowered computers, inadequate numbers of computers and software copies; and creating classroom environments "in sufficient abundance" that include LCD display panels, computers, screens, and projectors. Smallen concludes, "Senior administrators at colleges that are looking for information technology to reduce instructional costs are going to be disappointed. Quite the opposite is likely to be true!"

Speaking for the nation's research universities, Richard Katz acknowledges the significant role played by the federal government during the period 1947-1977 in funding technological investments, primarily to support research. Katz notes, however, the growing public distrust of research, the growing pressure on research universities to re-focus on undergraduate education, and the economic erosion of state support for public research universities. Nevertheless, Katz calls for "a substantial and focused campus investment" to

support campus computing environments. Needed are increased networking capacity, significant desktop platforms for students and faculty, print on demand capabilities, one-stop-shopping user interfaces, navigational and visualization tools, etc., all requiring, as Katz says, "significant continued investment in networks and integrative technologies."

According to Tom West and Steve Daigle, among the original goals of the California State University's Information Resources Management program were (1) providing students and faculty access to IT, and (2) building the intra-campus and inter-campus infrastructure to enable students and faculty to gain access to information and computing resources. They note, however, that given the scarcity of funding available, CSU campuses have been only modestly successful in achieving these objectives. In 1990, the CSU Board of Trustees endorsed a new set of initiatives calling for, among other things, increased access to desktop computing, media services, databases, and other external resources for students and faculty. Unfortunately, California's fiscal crisis has suspended implementation of these initiatives.

Bob Heterick wants all of this and more. In addition to individual desktop computing and access to the campus network, to broadcast and switched video and to the Internet, Heterick sees the need for "high tech" classrooms so that students and faculty are not constrained by the "open laboratory" approach. Learning in new ways is dependent on the development of a communications infrastructure, he says, which must exist at three levels: the campus itself must be wired with megabit delivery to the workspaces in classrooms, offices, and residence halls; a metropolitan area network that extends the campus infrastructure to students and faculty in the community; and a national infrastructure as well. He notes, regrettably, that the capital costs of creating the campus network seem "beyond the reach" of too many of our campuses.

I am reminded of an incident that I witnessed about a year ago at a meeting of campus presidents. The theme of the meeting was using information technology on campus. Many prominent national IT experts had been invited to speak, one of whom described the many activities going on across the nation and on his campus with great enthusiasm.

During the question and answer period, someone asked how many staff he employed to support these various activities, to which he responded, "About 700." You may or may not be surprised to know that these campus presidents did not rush to embrace his vision. Rather, their response was summed up in the private remarks of one prominent chief executive, who commented that this IT leader might be "the most dangerous man in America."

There appears to be an ever increasing gap between higher education's information technology "wish list" and the willingness of the public (defined as taxpayers, legislators, parents, and consumers) to pay for it. I recently participated in a meeting of an educational technology task force in my state. The topic was "wiring the campus." This group calmly drafted a statement endorsing what was conservatively estimated to be a \$100 million project! Faculty and staff in the State University of New York haven't had a raise in three years; campus budgets have been cut repeatedly. But wiring the campus for the benefit of the 20 per cent of students who live on campus and, of course, for the faculty was perceived as a reasonable goal to support. If we keep this up, no one is going to take us seriously. Instead of producing statements demanding access to technology directed to our own community (a wonderful case of preaching to the choir!), imagine addressing these statements to a group of parents or taxpayers and explaining to them why they should pay for what we want. Can we do it?

If we are going to be successful in persuading the public to support our goals for greater access to technology, we need to make a clear case that the benefits of doing so outweigh the costs. An essential part of making that case is implementing the ideas associated with reengineering. Penrod and Dolence have pointed out that the purpose of reengineering is to use the power of modern information technology to "radically redesign business processes in order to achieve dramatic improvements in their performance."¹ This concept speaks to the question of why one should invest in information technology. Unless we can make a convincing case that investments in information technology can make a difference in higher education, can address some of the fundamental problems facing us today, I cannot imagine how we will be able to pay for our wish list.

What are some of the challenges facing American higher education? First, as noted by Ron Bleed and West/Daigle, in the public sector of higher education, we face increased enrollment demand. This increased demand is not merely a result of the need to serve more students, although that is an important contributor. Now, more than ever, all sectors of

American society recognize that improving education and training is essential if the United States is to remain competitive in a global economy in the 1990s and beyond. This means that continued education, lifelong learning as it has been called, will increasingly become a necessity for large numbers of Americans.

Second, this enrollment demand is characterized by diversity. While most people associate diversity with an increase in the percentage of underrepresented populations—and this change is certainly taking place—the most dramatic change in the higher education student population is the increase in adult students. By the middle of the 1990s, traditional college students—those who proceed directly from high school to enroll full-time in an undergraduate program—will be a clear minority of all students in collegiate programs. Non-traditional students will constitute what is being called "the new majority" in American higher education. This new majority needs flexible ways to pursue their education as they simultaneously work and care for children.

Third, in the face of increased enrollment demand, the nation's colleges and universities face a combination of resource problems including:

- increasing costs that outpace the rate of inflation;
- crumbling facilities, a product of deferred maintenance;
- a diminishing supply of faculty; and
- increased workloads resulting in on-campus morale problems.

Finally, and perhaps most importantly, higher education, both public and private, must deal with the phenomenon of public mistrust: the feeling that American higher education costs too much and does not deliver.

I must take issue with Bob Heterick's suggestion that the higher education community can be divided into those who focus on effectiveness vs. those who focus on efficiency. This division suggests that those of us concerned about efficiency are not concerned about effectiveness; nothing can be further from the truth. I have never met anyone in higher education who is not concerned about the effectiveness of the teaching and learning process. I have, however, met many who disdain the idea that higher education must be efficient. It seems clear that the time has come for all of us to consider efficiency as an essential part of effectiveness if we want to survive into the next century.

What should the role of IT be? Should it be one of support or one of transformation? If we view its role as merely an add-on or a support to the existing paradigm of higher education, I do not think we will be able to convince anyone to pay for it. Katz and Smallen espouse the traditional view of IT: to support the instructional program or the research agenda. The decision to use IT in instruction (or not) rests solely with the faculty member. Yet most of our contributors acknowledge that the faculty are not especially interested in using

... imagine addressing [statements demanding access to technology] to a group of parents or taxpayers and explaining to them why they should pay for what we want.

¹James I. Penrod and Michael G. Dolence, *Reengineering: A Process for Transforming Higher Education*, CAUSE Professional Paper Series #9 (Boulder, Colo.: CAUSE, 1992), p. 2.

information technology in instruction. In the research university, the faculty have "reduced incentives" to learn about teaching; in the private liberal arts college, the faculty do not see the value of investing their time to incorporate technology into the teaching/learning process. If this is the case, why would parents or taxpayers support the financial investment requested? What exactly would the faculty do with all this stuff? As Lewis J. Perlman points out:

Without critical, structural changes in the system, placing more computers, videodiscs, and other gadgets into conventional classrooms will do nothing to reverse the failure of the education economy; it may actually make things worse. For one thing, we know from the extensive experience of office and factory automation that roughly 80 percent of the productivity gains from technology innovation come not from new hardware or software but from fundamental changes in management, organization, and human resources.²

Several of our contributors look to IT to transform the way we do business. Bleed's view of IT is that of an "enabler," helping the community college to achieve its goals of new communities and quality imperatives. According to Bleed, IT agendas are "attempting to capture the forces of change" in order to "energize the mission of the community colleges." His examples of IT applications include the use of electronic communications to extend the idea of community and to promote collaborative learning among well-prepared and less-prepared students; to provide instructional delivery of content; to provide services directly to students; to establish distance learning networks to increase access to higher education; and to establish school/community partnerships.

West and Daigle, in their description of Project DELTA, also advance the idea of using IT to develop a new vision of higher education to increase access to teaching and learning. While West/Daigle and Bleed are not specific about the cost/benefits of their approaches—something higher education must be able to demonstrate if we are to convince the public—nevertheless, they are clearly focused on making a "business case" for investing in IT. What is needed is a further explication of how we can use technology to re-think the organization of higher education.

Let me suggest a number of additional ideas that I believe we need to think about and address concretely as we take on this important task. Many of these ideas are embedded in the essays presented in this professional paper. Each focuses on the idea of using IT as an enabler to realize a new vision of higher education, one which serves an increasingly diverse student body in a cost-effective way.

²Lewis J. Perlman, "A New Learning Enterprise," *Business Week*, 10 December 1990, pp. 12-20ED.

- **We need to stop thinking about higher education as a "place."**

Images of our colleges and universities as Camelot, a sheltered grove—even as a mall—are becoming rapidly outdated. Whereas once the only way to organize an institution of higher learning was to amass resources (faculty, libraries, laboratories) in a single site and require students to travel there in order to access them, information technology is making this method of organization increasingly unnecessary. Bleed's vision of "a new learning community" which empowers students with the ability to learn seems to me the appropriate metaphor for the twenty-first century.

- **We need to find ways to foster inter-institutional cooperation in teaching and learning.**

Networking is rapidly increasing cooperation in the research enterprise, but it has had remarkably little effect on the teaching and learning enterprise. Heterick speaks of moving from an industrial age model of higher education to one suited to the information age. While I agree wholeheartedly with his approach, I am unconvinced that our colleges and universities have reached the industrial age. They seem to me more like small businesses or small family farms, individual

islands producing individual courses, duplicating one another's educational services without regard to the cost effectiveness of the approach. We need to find ways to utilize the power of information technology to offer instruction cooperatively. By joining together across institutional boundaries, we may be able to realize some

economies of scale and, in doing so, radically increase the learning resources available to our students.

- **We need to create new models of teaching that leverage faculty time and expertise.**

As part of an ongoing study of the cost of higher education, William Massy draws an analogy between colleges and universities and professional service firms in law, accounting, and consulting, all of which rely on the services of highly trained professionals. Massy points out that productivity improvement in professional service firms is obtained mainly by substituting less expert and hence less costly people for those with higher levels of expertise. The rule is, "always use the least expert resource that can do the job."³

While universities have done this to some extent by using graduate assistants in research and teaching (with the attendant gains in faculty time for research and publication), we have not thought enough about ways to reduce the costs of undergraduate education by developing new forms of

If we view [IT's] role as merely an add-on or a support to the existing paradigm of higher education, I do not think we will be able to convince anyone to pay for it.

³William F. Massy, "A New Look at the Academic Department," *Policy Perspectives*, The Pew Higher Education Research Program, 1990.

teaching and learning. Imagine, for example, a large electronic "virtual lecture hall" consisting of a satellite-based delivery system broadcast to hundreds of students simultaneously with teaching assistants providing individualized attention and feedback via electronic mail to small sub-sets of the "class."

What should the role of IT professionals be in this discussion of change? Katz suggests that the debate over how higher education should or should not balance research incentives with the need to educate students or to contribute to the community is, in his words, "outside the purview of information technology executives." An alternate view of the relationship between the "business" of an organization (in the case of higher education, the business is teaching and learning) and information technology is suggested by John Roberts, vice president of corporate research and technology at UNUM Life Insurance, in a discussion of prototyping in *IBM Directions*.⁴ As organizations move beyond basic automation, IT professionals need to take on the more complex role of helping to redesign business processes.

Roberts describes a phenomenon with which we are all familiar: new technologies with new capabilities lead to a phase where it becomes more difficult for both the systems and the business people to envision how they want to run the business. "Technology is not going to be a barrier; the barrier, I think, is going to be determining how the business person envisions the design of the business." Roberts' point is, I believe, that the "business people"—in our words, the faculty and administration—cannot fully understand the benefits offered by IT or envision new ways of doing business that may be possible. As Roberts says, "It's hard to envision what

you haven't seen or done." This idea suggests a role for IT and IT professionals in higher education that goes beyond support to working collaboratively with faculty and administrators to establish a vision of a redesigned or reengineered approach to teaching and learning.

The good news is that American higher education has a rich history of reengineering itself. West and Daigle note that the public comprehensive university has, in a sense, been reengineering itself since its inception thirty years ago. Katz also points to another period of reengineering at the end of World War II when the passage of the G.I. Bill inspired the university to reorganize in order to provide mass education. The 1960s brought increased access for underrepresented minorities, and the 1990s are seeing adult learners entering higher education in unprecedented numbers.

From the days of the creation of the colonial colleges, those "temples of piety and intellect in the wilderness," whose purpose was to shape society's future rulers, to the emergence of the land grant institutions, developed to meet the needs of a newly industrialized America, American higher education has steadily moved in the direction of the idea that, in the words of the first president of the University of Michigan, higher education is "not a luxury but a necessity that should be made available to all." Why should the goal of all of American higher education not be that of the Maricopa Community Colleges?

To create accessible, effective and affordable environments for teaching and learning for the people of our communities in order that they may grow personally and become productive citizens in a changing and multicultural world.

Information technology viewed as an enabling force, coupled with a vision of change, can put this goal within our reach.

⁴"Bridging the Gap between I/S and Users," *IBM Directions*, Summer/Fall 1991, pp. 20-23.

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A Third Opinion from Camelot

by Thomas F. Moberg

These essays provide fascinating perspectives on the potential for using information technology to reengineer the teaching and learning processes in higher education. Both optimists and pessimists will find things to agree with in the varied opinions of the six authors. In spite of occasional humbling episodes of over-enthusiasm in my years as a college teacher and administrator, I generally find myself aligned with those



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who are optimistic about the transforming potential of information technology. I think information technology will have an increasingly significant impact on educational institutions of all types, not just around the edges in a marginal way, but at the very core of how teaching and learning take place, and that applications of information technology will lead to fundamental changes in liberal arts colleges.

A liberal arts college, as David Smallen explains, often does seem like an "educational Camelot" to those of us who work in one. Such institutions place the highest premium on good teaching and close faculty-student interactions. Faculty research is encouraged and even required in liberal arts colleges, but the research program is closely tied to teaching. Undergraduate students can be deeply involved in faculty research at all levels. Both faculty members and students prize the close mentoring relationships which are built into this mode of teaching.

Liberal arts colleges have much in common with larger colleges and universities. For example, liberal arts colleges are very concerned about diversity, cost containment, student aid, faculty productivity, physical plant maintenance, and public perceptions of education. And such colleges share the general concern about making it possible for undergraduates to have access to information resources and technology. While liberal arts colleges in general are suffering from the same fiscal difficulties as other areas of higher education, there is no perceived crisis about the style or quality of education at these institutions. So the notion of reengineering as an antidote to critical problems with the basic nature of the institution does not really apply here. Nevertheless, I believe that information technology will change liberal arts education in fundamental ways.

Everyone who works in higher education knows that teaching and learning are evolutionary, interactive processes. Rarely do faculty members teach the same course the same way twice. New fields of inquiry and study emerge, often as "cross-disciplinary" or "multi-disciplinary" hybrids. This will continue to happen with or without the use of information technology. But the drive to make more effective use of computing and networking resources which are already in place will cause major changes whether or not this effort is planned as a deliberate strategy of improvement.

If we take "reengineering" to mean a substantial, deliberate, planned shift in a process or system, then it may not be appropriate to call what is likely to happen in teaching and learning a reengineering. The change process will be partially planned and partially accidental, probably with a trail of failed experiments, wasted resources, and frustrated hopes along the way. But there are glimmerings that significant change will take place, that teaching and learning will be profoundly affected, and that in the long run, students and faculty will be interacting with each other and the information world in new and substantially different ways.

Liberal arts colleges may actually be transformed by the impact of information technology faster than other types of educational institutions. One major difference between liberal arts colleges and universities is the level of student access to IT resources. Richard Katz notes that nationwide, public and private universities provide one dedicated instructional PC or workstation for each forty-five students. At

good liberal arts colleges, the level of access to computing and networking resources is much better than this. For example, Kenyon College, a liberal arts college with 1,500 students, currently provides one computing station for about every nine students. Nearly every Kenyon student uses some form of college-provided computing resource every week of the academic year, and every student has the option of getting a residence room connection to the campus network. Also, every faculty member and every staff "knowledge worker" has standardized desktop computing equipment and full access to the campus network. Kenyon has a well developed computing and networking environment, a comprehensive library automation program, and a commitment to using information technology as a strategic asset. This type of information technology environment, increasingly typical in liberal arts colleges, provides the basic infrastructure to allow profound changes in teaching and learning to take place.

Before going further in an optimistic vein, it would only be honest to admit that many of us who have been promoting the use of computing in education for the past two decades have occasionally been wrong. We have sometimes been guilty of naive and excessive enthusiasm about the value of

the technology to enhance education. My own most memorable failure in this regard was when I tried to convince faculty colleagues who taught non-English languages of the great possibilities inherent in the use of computers to enhance instruction. Unfortunately, I eventually

discovered that neither the software nor the hardware available then was capable of handling the non-English text adequately. It was an embarrassing and sobering experience. So even if we are enthusiastic about the possibilities of reengineering teaching and learning, we should keep remembering our past mistakes.

With that caveat, let me offer three examples drawn from my own experience of ways in which I believe information technology is significantly affecting teaching and learning. These three examples in a sense cover the past, present, and future applications of information technology in liberal arts education. The first example involves the use of computing to enhance the instructional process in particular courses, something which has been occurring in higher education since the 1970s. The second example expands the first by illustrating how state-of-the-art technologies not only enhance instruction, but change the fundamental form of the curriculum. The last example suggests that the entire nature of undergraduate education will change when students and faculty have wide, easy access to the information world.

Example 1:

When time-sharing computing became widely available at liberal arts colleges in the 1970s, many faculty members began experimenting with ways to use computing

... the entire nature of undergraduate education will change when students and faculty have wide, easy access to the information world.

to enhance teaching and learning. Most of us didn't have any particular vision about transforming the curriculum, but were looking for better ways to teach the standard subject matter in our disciplines. In retrospect, many of our attempts were silly and naive, limited in major ways by the hardware, the software, and our own imaginations. Both the software and hardware have improved tremendously since that time, and the experiments have continued, with some notable successes and obvious failures.

Statistics and mathematics are among the areas where computing has been relatively successful in enhancing instruction. I have come to believe that the discipline of statistics, my field, simply cannot be taught well without incorporating computing as an integral part. Numerical calculation of complicated statistical formulas is an obvious example where electronic computation is essential. But, more importantly, computing makes it possible to use *simulation* as an intuitive and practical technique for illustrating and studying key statistical concepts (e.g., sampling distributions) which are difficult for students to understand theoretically.

As a general mode of inquiry applicable in many scientific areas, computer simulation lies somewhere between pure scientific theory and laboratory experimentation. This methodology was not practically feasible before the advent of modern computing, but has now developed into a respectable mode of scientific inquiry. And as a teaching technique, simulation continues to offer new possibilities for teaching about both simple and complex topics.

The computer-based exercises I used in statistics courses at all levels allowed me to teach standard but complex topics in new ways. When I wrote computer programs to illustrate difficult concepts, I gained a deeper understanding of the statistical processes, and was thus better able to explain them to students. I learned something new about both the statistical concepts and ways of teaching them every time I used the computer-based exercises. Although my use of computer technology didn't substantially change the content of the courses, the technology enhanced and expanded the teaching and learning modes. In many ways, my personal optimism about the value and potential of information technology in liberal arts education stems directly from my own experiences in teaching statistics.

Example 2:

Many of the uses of instructional computing which began in the 1970s were inherently constrained by the technology available. In particular, use of graphical representations was severely limited by the physical medium. Fortunately, the technology has now advanced to the point where teaching applications we could only imagine in the past are now possible. For example, computer technology has made *visualization* a powerful tool which is changing not only the

way faculty teach, but the basic content of the courses they teach.

In the mathematics curricula of many liberal arts colleges, the use of powerful, graphics-oriented programs such as MAPLE, MACSYMA, and DERIVE has not only enhanced the pedagogical style used in teaching concepts, but has altered the mathematical ideas and methods covered in the courses. In calculus, for example, students spend less time on such things as brute force integration and differentiation. Instead, greater emphasis is placed on basic concepts (e.g., key points in functions where maxima, intercepts, and flex points occur) which are taught and studied from a graphical perspective. Classrooms are equipped with graphics workstations for each student, while the instructor presents course material using graphical display devices and software which allows the use of three-dimensional representations in color. The technology allows the teacher to represent information in visually creative ways, working interactively with the class to explore ideas.

The natural science curriculum is also being changed by the use of visualization and computational tools. At Kenyon College, for example, faculty members from biology, chemistry, and psychology are collaborating to develop a molecular modeling laboratory based on a software package called HyperChem running on networked 486-level microcomputers. This state-of-the-art software makes it possible to illustrate concepts which could not be simply explained any other way. The availability of the visualization technology led the faculty to begin working on this project in a new area of scientific study. The use of the molecular modeling laboratory is already fundamentally changing the way faculty think about and teach this multi-disciplinary topic, the way faculty and students collaborate on research projects in general, and even more mundane issues like optimal class sizes, procedures for assessing student work, and allocation of future instructional resources. As with the use of visualization in mathematics courses, the molecular modeling technology has changed both the mode and content of the curriculum in some science disciplines at Kenyon.

Example 3:

The rapid growth of the Internet promises revolutionary new options for using information to fundamentally alter both curricula and pedagogy. As noted earlier, most liberal arts colleges have a basic campus computing and networking infrastructure in place to allow easy access to the Internet. At this stage, however, relatively few faculty members and students know how to navigate the new electronic world of local and remote library catalogs, international conferences and bulletin boards, and campus-wide information systems.

While library and computer center staffs generally offer instruction in the use of both computers and library resources, usually under the separate rubrics of "bibliographic

*The rapid growth of the Internet
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instruction" and "computer literacy training," there is an obvious need to help faculty and students learn to use new information resources and technologies more effectively. This should be the next major step in developing a campus information environment which fully supports undergraduate education. For example, significant undergraduate research, a hallmark of liberal arts education, can be substantially enhanced when faculty and students know how to use technologies such as networked, microcomputer-based CD-ROM stations to search for information, and are then able to sort, organize, and synthesize that information effectively. These activities transcend and blur the existing functional lines between the college library and the computing organization, and suggest that the traditional instructional activities of these organizations need to blend.

A project under way at Kenyon illustrates how access to information is likely to change entire parts of the curriculum. Using grant funding, the college has launched a project designed to incorporate new information resources and technologies into the first and second year curricula by giving faculty and students opportunities to collaborate on learning projects and course development. Over three years, about 40 percent of Kenyon's faculty from all discipline areas will participate in summer institutes which focus on exploring potential uses of new information technology resources. The faculty development activities will be jointly led by library and information technology staff members. Students will be the ultimate benefactors of the program as they gain new abilities to search the information world and use what they find.

As an example, one of the Kenyon courses which will be "reengineered" to use information technology in new ways for teaching and learning is called "Expansion of International Society," team-taught by faculty from the departments of Political Science, History, Asian Studies, and Modern Languages & Literatures. The basic goal of the course is to help students develop a common historical view of the contemporary world system and the forces which have affected it. In addition to the traditional printed materials, the primary course materials will include spatial and temporal data such as maps and timelines presented interactively using computer graphics; film, video, and still imagery available via the campus network as well as by traditional media delivery systems; international correspondence through scholarly discussion groups on the Internet; news feeds of global events; and local, national, and international library re-

sources. Both faculty and students will be learning how to use such resources efficiently, a process which will have a significant effect on both the content of the curriculum and the style of pedagogy. Such an approach would not be possible without the use of information technologies.

These examples show several ways that information technologies can alter the basic nature of the teaching/learning process. As these trends continue, I believe the changes will become more pronounced. The use of information networks will increase and improve student-faculty interaction, although not all of it may be face-to-face or in the usual instructional venue of the classroom. The traditional collegial interaction among faculty which takes place on campus and, increasingly, around the world via the Internet, is being replicated in student-to-student and student-to-faculty contacts at all levels. As faculty and students become more sophisticated at using online conferences, bulletin boards, electronic mail, campus-wide information systems, and information-seeking software which roams the Internet, the impact on both curriculum and pedagogy will be dramatic and profound.

Information technologies can enhance the best characteristics of teaching and learning in liberal arts colleges. While this may not be the result of an organized reengineering effort, there will be fundamental changes in both the curriculum and the pedagogy because of new information resources and technologies. Faculty will move from the older modes of instruction, such as lectures, to new flexible styles and formats which involve a wide variety of media delivery. Traditional textbooks will increasingly become multimedia materials which might involve books tailored for each course,

individualized audio and video materials, interactions with experts, electronic conferences, and so forth. In liberal arts colleges particularly, the emphasis on close faculty/student interactions will expand to mentoring in both traditional instructional settings such as labs and studios, as well as new forms involving electronic communications

both on and off the campus. As students learn to locate information in old and new forms through the Internet, and develop new skills to access, organize, and synthesize that information, they will increasingly be able to participate fully as informed, responsible world citizens in the information age. This is one of the fundamental goals of liberal arts education.

As faculty and students become more sophisticated at using online ... [resources], the impact on both curriculum and pedagogy will be dramatic and profound.

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'Growing' Our Academic Productivity

by Polley Ann McClure



Polley Ann McClure is Associate Vice President and CIO at the University of Virginia, where she is also a professor of environmental sciences. Formerly she was Associate Vice President for Information Resources at Indiana University, where she was responsible for leadership, planning, policy, and coordination of information technologies at IU's eight campuses.

The authors of this collection of essays have done an outstanding job of describing the status of technology support for instruction in their very different types of institutions and of providing insight into the complex business of introducing change within academe.

I was provoked, however, to ponder the question of whether the basic idea of "reengineering instruction" isn't, somehow, fundamentally flawed. I also think that in some respects the essays miss a very key point: An important object of reengineering is the improvement of academic productivity, not just increased teaching effectiveness at any cost.

Reengineering has its origin in the field of industrial engineering and quality assurance. A manufacturing process exists to accomplish the particular function of building some tangible product. The objective of the reengineering effort is usually to increase the yield of that product per unit of cost or time or to improve its quality. The numbers produced and their quality are routinely measured, and improvements can be objectively monitored. The manufacturing process usually involves the work of many individuals and departments and is, therefore, a collective process of the enterprise. Management has ultimate responsibility for the process and also the authority to make necessary improvements.

The reengineering concept has been extended to improvement of business processes as well. The basic approach is the same; a process is analyzed as a sequence of steps along a value chain with the main difference being that the end product is a service rather than a tangible object. But, again, the business process is normally an institutional process, directly in the authority sphere of management, there is agreement about the output of the process, and quantity and quality of output are measurable.

Although they share some attributes, institutions of higher education are not the same kinds of organizations as factories or even service providers. Universities and colleges really are communities of scholars, loosely organized groups of semi-autonomous faculty who retain authority over the teaching and research processes. The administration manages the business and support functions and has limited access to the academic processes themselves. Furthermore, the academic processes of teaching and scholarship are usually not even collective processes of the faculty. They are practiced for the most part independently by individual professors and their students and support staff. Scholarly disciplines transcend the individual institutions in which professors work, and faculty sometimes identify more strongly

with their disciplines than with their institutions.

In many ways, academic institutions, as conservative as they are, already represent the "ideal" organizational structure of many reengineering efforts: empowered individual workers and small teams with essentially final authority and responsibility for the work product and the processes that produce it. The academic side of most institutions of higher education represents one of the "flattest" organizational structures around. Department chairs have a "span of control" of sometimes fifty faculty, not to mention staff. Deans may have responsibility for twenty to thirty departments in a large institution. Add a provost and a president to the hierarchy and you have five layers, at most.

Because of these differences between educational institutions and more typical hierarchical organizations, I think efforts to "reengineer instruction" will have very limited success. You cannot reengineer a process that you do not control. Instruction takes place largely through the personal creative work of an individual teacher, not through a process that management can redesign. Furthermore, there is little agreement about the nature of the output: educated students. We are sure that just counting graduates is an inadequate measure of quality of instruction, but we have no other generally accepted measures. Many of the "indicators" we use for educational quality are more measures of input variables than of outputs and probably are negatively correlated with overall academic productivity (for example, the *US News and World Report* rankings are based on FTE faculty to FTE student ratio and total educational expenditures as measures of quality of education). Efforts to reengineer instruction will be severely limited in the absence of clear measurable outcomes.

I'm not arguing that colleges and universities can just ignore the social and economic realities of our times and continue to do business "as usual," or that we have no responsibility to improve academic productivity. Like the authors of these essays, I believe that in the long run, information technology will play a key role in supporting that improvement. My point is that the time scale and methods available to us as academic leaders may be quite different from those used in industrial or business enterprises.

I've always thought about administration in higher education as a nurturing process, more like gardening in its approach and methods than like engineering. In both pursuits, judgments about quality are largely subjective, yet people usually agree about which gardens are pretty. You try

to shape outcomes mainly by selecting the right environment to help an individual flourish and grow, providing resources selectively, and sometimes doing a little pruning. But you don't generally reengineer your roses or most university faculty.

I'm going to be bold and claim that, while the "p" word is not used frequently in this professional paper, academic productivity improvement is what it is about. We all understand the financial constraints our institutions are facing, and we want to help them "do more with less." Productivity is defined generally as the ratio of output of a process to the input (like cars built per dollars invested). In keeping with this definition, then, we are seeking, in this context, not just to improve educational output at any cost, but to improve the ratio of output to cost—however we measure it, the amount of learning per dollar spent. This is where we run into a problem with technology solutions, especially for improvement of instruction. While there are some cases in which we can document an improved educational output as a result of the technology intervention, in a brief survey of the literature, I could find no studies documenting improved educational output per unit of cost. The educational gains from information technology typically have been at huge cost, in terms of the investment in both equipment and software, but more significantly, in faculty and support staff time.

While I don't want to claim too much similarity with the business sector, there is general agreement from that arena that the overall gains in productivity from information technology have been much smaller than would justify the investments that have been made (the "productivity paradox"). Some studies even claim that productivity has declined as a result of infusion of information technology.

This leads me to the realization that a critical factor for our reengineering efforts is not so much how we "incent" faculty to make major time investments to develop instructional applications or how we convince presidents to make large investments in equipment and facilities. The critical factor is to either decrease the costs in a major way or increase by many fold the amount of learning (either number of students or amount each student learns per dollar).

This viewpoint puts faculty time squarely on the cost side of the ledger sheet, thus a variable to be minimized or held constant. It makes clear the fallacy of many efforts by public agencies that position faculty instructional time as a variable to be maximized rather than conserved. This would serve to drive instructional costs up, not down, with decreases in productivity rather than the converse. This is particularly true in research institutions where the delicate balance of time spent by faculty on teaching comes at the expense of research with its important effects on the reputation of the institution and its fiscal resources.

It seems to me that if we are to try to cultivate our institutional gardens with the goal of improving academic productivity, our focus right now needs to be on non-labor-intensive applications of technology that can leverage faculty effectiveness. Without spending more total time on teaching, can we enable better communication and engagement with more students? Can we produce tools to cut through the hours of manual grade-keeping and transcribing? Can we develop secure and auditable mechanisms for keeping grades and transferring them electronically? What about degree-audit applications to increase the efficiency of academic counseling? Or applications to take references directly from a database search, store them, and search them

to make finding examples easier? I'm selecting these approaches rather than distance education, high technology classrooms, or multimedia initiatives, because of the massive difference in cost and unclear relation so far between the investment and improved learning. If we make

good decisions about our institutions' information architecture and the technology to support it, the infrastructure we build (and write off as a part of the cost of these administrative applications) will also serve to enhance the environment for improved academic effectiveness.

Paradoxically, the best bets for improving instructional productivity might be investments in information technology to support administrative functions. There are many examples of significant net cost savings coupled with improved function from automation of administrative transactions within higher education (for example, in the publications of CAUSE and NACUBO, the National Association of College and University Business Officers). The difficulty with these is that rarely have the institutions involved effectively captured the savings and reinvested those in direct support of teaching. But if this were done, with the savings invested in more creative teachers, information technology would have made a substantial contribution to academic productivity.

As gardeners in academe, I think the most powerful ways to improve productivity of our gardens is, first, to hire the best faculty we can attract (you rarely produce prize tomatoes with scraggly tomato plants); second, to provide an environment rich in the raw materials they need to grow (in academe that means libraries, computers, laboratories, and other good minds for stimulation); and, third, to ruthlessly weed out the competitors for resources, such as inefficient administrative processes, so that the light and water we do have go directly into the academic process. Information technology resources play a role in all three: attracting the best, nurturing their growth, and facilitating their work, and making administrative functions more efficient to allow limited institutional funds and time to be directed into the academic mission itself.

... while the "p" word is not used frequently in this professional paper, academic productivity improvement is what it is about.

Reengineering or Just Tinkering?

by Don Doucette



Don Doucette is Associate Director of the League for Innovation in the Community College, a 24-year-old consortium of resourceful community colleges organized to promote experimentation and innovation in community college development. Dr. Doucette directs the League's initiatives, in partnership with technology-related corporations, in applying information technology to the challenges facing community colleges.

I would normally think of it as a hopeful sign that respected and thoughtful representatives of our higher education community would agree to consider the proposition that teaching and learning in their institutions might be reengineered to take advantage of the tools now provided by information technology. However, as insightful as the perspectives contained in this volume are about the dynamics at work that make reengineering more or less likely, more or less desirable in different higher education environments, the lingering impression after reading these analyses is that we are tinkering much more than we are reengineering.

Of course, these perspectives range enormously on the tinkering to reengineering scale. On one end of the spectrum, David Smallen suggests that the model could not be better than the traditional Aristotelian one practiced at his admittedly fine small liberal arts college—that reengineering is not only suspect but actually undesirable. On the other end, Ron Bleed describes his community college district as an already reengineered model for applying information technology to improve access to resources, enhance communications, increase faculty productivity, build communities, and serve students better. Perspectives from research and comprehensive universities fill out the volume and fill in the middle of the spectrum, with the “sheltered groves” of research universities siding with the yes-but-we’re-different (read “special”) view of liberal arts colleges and the “malls” of the comprehensive universities joining community colleges in more active examinations of doing things differently.

Perhaps my disappointment is that of the perspectives represented here, only the community college voice approaches with any seriousness the idea of not only doing things differently, but the imperative of doing different things. Bob Heterick gets it right when he summarizes the principal challenge facing higher education: “... the problem might be stated as providing the most effective learning, most efficiently delivered, consistent with the budgets we are likely to receive.” He realistically notes that some institutions will be attempting incremental changes while others attempt more serious reengineering, but his acceptance of such tinkering with the system as appropriate appears to underestimate seriously the social and economic forces at work in society that will mandate, not request, fundamental change in the way higher education does business.

The economic imperative

Those who would tinker with incremental change misread the magnitude and rapidity of the change going on

outside their ivy-covered walls. While it is understandable how one could dismiss as merely interesting theory the many claims of imminent or ongoing paradigm shifts announced in both the popular and scholarly press, it is difficult to argue that higher education will remain unaffected by the fundamental economic restructuring that is occurring in our corporations, in government, and in all of our social institutions. Does higher education really think itself immune? Is tenure really more secure than lifetime employment at IBM or McDonnell-Douglas?

The facts are these: For the first time in the 33-year history of reporting data on state appropriations, Ed Hines’ *Grapevine* report for fall 1991 showed an actual decline in total dollars appropriated by states to higher education. For a survey that has usually reported 8-10 percent annual increases, this was big and disturbing news. As Kay McClenney, vice president of the Education Commission of the States, points out, “Higher education is clearly competing with other public priorities.” Chief among them in state budgets are Medicaid, corrections, and interest on state indebtedness. Given the fact that support for higher education doubled during the 1980s and increased in real terms over inflation by 27 percent, “From the typical legislative perspective, higher education is a well-fed child who has now grown up and can earn its own way in the world” (*Leadership Abstracts*, September 1992). There is simply no more money to go around, and decreasing funding levels for higher education are a permanent condition.

If states can no longer subsidize higher education, then the burden must fall on users. This trend has been evidenced by recent increases in public college and university tuitions by as much as 25, 30, even 40 percent. However, such increases cannot be sustained by users, many of whom are themselves struggling with the effects of a radically restructuring economy. The economic model for higher education has become unsustainable. Higher education does not have a choice about whether it becomes more efficient and productive. Irresistible economic forces will force it to abandon its labor-intensive, classroom-based, contact-for-credit-model—whether or not it is deemed the most effective. Hard economic facts pay little heed to professional preferences, as doctors, prison guards, and others will also find out as limited resources force transformational changes in other government-supported industries. “Reinventing government” is not just the title of a best-selling book read by all of the players in the incoming Clinton administration; it is a pragmatic course of action for state and local governments that are

redefining their roles in providing services to match economic reality. "Reinventing higher education" must be more than a catchy conference title if we are to have a hand in defining our future role—rather than have it handed to us.

Doing different things

Higher education does not have a choice about its main work. As long as economic conditions permit, colleges and universities can choose their relative emphases. In good times, legitimate arguments about preserving culture and creating new knowledge are convincing. However, when dollars cannot support both scholarship on the sculpture of Classical Greece and worker training for the developing biotechnology industry, training will win the competition every time. The higher education community has the responsibility to balance its efforts so that this dichotomous choice is never forced. It must police its excesses so as to not weaken its claim of the timeless importance of scholarship and truth. It is not an accident that the increasingly theoretical emphasis of research in economics has been given short shrift by the hard-nosed pragmatic policy concerns of the new administration.

Despite the fact that we have held up the research university as the model for all of higher education, the preparation of scholars and the creation of new knowledge has been a declining emphasis of our system of higher education for decades. Now, as we get serious about having to compete in a global economy—forced to do so by tangible evidence that declining personal standards of living are the very real alternative—the main task of higher education is undergoing a transformation. Rather than focusing on the education of youth and the preparation of new entrants into the work force, the main work of higher education is becoming the education, training, and retraining of the existing work force—largely, place-bound and time-bound adults. The implications of this shift for delivery mechanisms have been explicated well by others, but small seminars in upstate New York, or even urban California, are not likely to fit the new model very well.

Again, economic reality will force fundamental changes in the higher education model whether or not we concur. Restructuring the content and delivery mechanisms of higher education to reflect the urgent needs of the society is not open to serious debate. The populace will insist on help in maintaining its current standard of living, and it expects higher education to deliver the goods. The public will not support a system that acts oblivious to its bread and butter concerns.

Serving new communities

While increasing access to higher education has been a national goal since the late 1940s, no one pretends that the

system has been able to avoid a degree of socioeconomic stratification. Yet, the conspicuous consumption of the 1980s and the underlying class tension that has grown closer to the surface now make blatant inequality of educational opportunity less tolerable, especially in our public institutions.

Only at great risk can higher education ignore the aspirations of a burgeoning population of a young, ethnically and racially diverse working class for upward economic mobility based upon educational attainment. It is not too difficult to imagine colleges and universities becoming the targets of rage if they are perceived exclusively as citadels of privilege. For practical reasons, they must reach out to serve all of those whose aspirations require education and training, and upon whom the nation's economic fortunes depend—not just cream off the top without substantial broad-based benefit. However, serving new and diverse populations will mean fundamental changes, only some of which are related to the applications of information technology implicit in the preceding discussion.

Yet, the point remains that the status quo in higher education will not survive the economic and social dislocations we are just beginning to experience. My persistent idealism suggests that colleges and universities may have some special role to play in rebuilding and reuniting the communities that have fractured outside their walls. Idealism aside, higher education needs to reinvent itself and redefine its relations to its various communities if only to retain public support from an increasingly diverse population that may not have the universal faith in the system that we have come to take for granted. Higher education may have to re-earn the public's trust.

So, while the idea of opening the discussion on how higher education might reengineer teaching and learning in its institutions seemed so promising, I must admit to being disappointed by the lack of boldness in the visions expressed in this volume. While I have never thought of myself as a proponent of what Bob Heterick calls the Mario Andretti school of change—"If everything is under control, you're going too slowly"—I find myself disheartened that too often our best and brightest seem destined to respond only with great reluctance to societal changes afoot in the land. How much more fitting it would be for higher education leaders to rise above the tumult to chart a new course and to craft new communities, not only for their institutions, but also for society. Instead, it appears the agenda of change will be force-fed from outside the walls.

If reengineering is our real agenda, the discussion must focus on the participants in the teaching and learning process. Substantive reengineering can occur only if the student replaces the faculty member at the center of the process—

Rather than focusing on the education of youth and the preparation of new entrants into the work force, the main work of higher education is becoming the education, training, and retraining of the existing workforce—largely, place-bound and time-bound adults.

maybe the only fundamental change in the paradigm since Socrates. It should not be surprising that there is precious little discussion about what it means to design a student-centered learning process, for our entire higher education culture is based upon the presumption of faculty prerogative. The joke that the research university would be a fine place if only it could be rid of the distraction of students is not funny, just telling. It may be time to be honest about what functions of higher education might be more competitively carried out by research laboratories, publishing houses, software development firms, and think tanks. Public support could be

focused on work that has public priority, rather than lost in indirect costs to support ill-defined missions.

There are, however, glimmers of light. There are some who understand the student to be the center of the higher education universe. The Maricopa Community Colleges have much to teach about student-centered design of learning systems. At least they get the challenge right. Although I understand it is unfashionable to be apocalyptic, my reading is that too much of the current discussion of reform in higher education is about rearranging the deck chairs on the Titanic, rather than reengineering the hull. It is just tinkering.

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EDUCOM's Educational Uses of Information Technology (EUIT) Program

EDUCOM's EUIT program undertakes activities around the country that promote (1) the national development of information technology as a resource in higher education; (2) improved faculty and student access to information technology; (3) more effective and varied forms of teaching, learning, scholarship, and research through information technology; and (4) professional development programs for faculty and staff.

EUIT programs usually involve national partnerships with the higher education and library communities, professional and disciplinary societies, government, and information industries to improve the quality and accessibility of higher education through the use of information technology.

Currently, EUIT's projects include:

- *The Jericho Project*, a national effort to help faculty and staff share the information and develop the skills and insights needed to take advantage of available, affordable information technologies.
- *Dilemmas in the Ethical Use of Information*, which addresses important issues regarding individual and institutional rights and responsibilities in the ethical and legal uses of information technology.
- *Equal Access to Software and Information (EASI)*, which helps colleges use adaptive technology effectively to promote independence and academic success among students and faculty with disabilities.
- *Software and Curriculum Innovation Awards Program*, which annually recognizes individuals, companies, and institutions for their accomplishments in using information technology to improve teaching and learning.
- *Valuable, Viable Software*, which is publishing a book of case studies about the value and viability in

higher education of particular computer and video-based software.

- *How to Write Publishable Software*, which is publishing a guide about how faculty can publish and distribute their software products.
- *User Documentation Exchange*, which involves over sixty institutions exchanging user documentation.
- *Faculty Support*, which fosters online communications among computer support professionals about how to serve teaching and learning.
- *Network Licensing of Application Software*, which is developing a report on the licensing process.
- *Preferred Visions*, which is developing a preferred vision of the future for educational uses of information technology.

The following titles are available in the EDUCOM Strategies Series:

- Anandam, Kamala, ed. *Transforming Teaching with Technology: Perspectives from Two-Year Colleges* (1989).
- Graves, William H., ed. *Computing Across the Curriculum: Academic Perspectives* (1989).
- Ringle, Martin, ed. *Computing Strategies in Liberal Arts Colleges* (1993).

Also available from EDUCOM:

- Boettcher, Judith V., ed. *101 Success Stories of Information Technology in Higher Education: The Joe Wyatt Challenge* (1993).

For more information: EUIT Program, EDUCOM, 1112 16th Street, NW, Washington, DC 20036; 202-872-4200; e-mail EUIT@BITNIC.EDUCOM.edu.



Company Profile

Digital Equipment Corporation is one of the world's largest suppliers of high-quality networked computer systems, software, and services.

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Digital recently opened a new era of computing with the introduction of Alpha AXP™, the world's first and fastest 64-bit RISC computer chip. An entire family of Alpha AXP computers which run OSF/1, OpenVMS, and Windows NT™ software has been introduced and are already being used at educational institutions as powerful engines which enable new dimensions in educational computing to be reached.

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A commitment to provide education with the most technologically advanced tools possible has been central to Digital's philosophy since the company was founded. That commitment was re-emphasized with the introduction of The Education Initiative (TEI), a comprehensive set of programs to make Digital's computer technology more accessible and affordable to education professionals.

Advances in campus networking and computing technology have resulted from Digital's many research partnerships with pioneering educational institutions. World-class advanced research and application development is being performed in top universities, colleges, and community colleges worldwide under Digital sponsorship.

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For example, Digital's eight-year partnership with the Massachusetts Institute of Technology and IBM, called Project Athena™, resulted in DECathena™, an efficient, cost-effective way to manage large numbers of intelligent desktop workstations in a network.

Since joining the association in 1981, Digital has participated in the CAUSE conference annually through presentations, sponsorships, and exhibits. The CAUSE office administrative computing system is supported by a MicroVAX, with a PATHWORKS-based LAN.

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In late 1992 Digital introduced the first workstations and servers using its Alpha AXP advanced 64-bit architecture. More than 1,000 systems were sold to educational customers worldwide within the first few months.

RESOURCE LIST

ASSOCIATIONS AND OTHER ORGANIZATIONS

AGENCY FOR INSTRUCTIONAL TECHNOLOGY is a non-profit US-Canadian organization which develops video, videodisk, software, and print materials for schools in association with state, provincial, and local education agencies. For information: AIT, Box A, Bloomington, IN 47402-0120; 800-457-4509.

ANNENBERG/CPB PROJECT has accumulated a great store of experience and contacts involving the application of computing, video, and telecommunications to the improvement of education. For example, its program "New Pathways to a Degree: Using Technologies to Open the College" has helped to pioneer rethinking of degree programs. For information: Stephen C. Ehrmann, The CPB/Annenberg Project, 901 E Street, NW, Washington, DC 20004-2037; 202-879-9643; e-mail sehrmann@linknet.com.

ASSOCIATION FOR THE ADVANCEMENT OF COMPUTING IN EDUCATION is an international educational organization offering publications and conferences for researchers, professors, developers, administrators, and individuals with an interest in IT in education. For information: AACE, PO Box 2966, Charlottesville, VA 22902; 804-973-3987.

ASSOCIATION FOR EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY is dedicated to the integration of technology into education, providing assistance to educators with the changes and challenges that face them today from films to overheads to interactive video and hypermedia. For information: AECT, 1025 Vermont Avenue, NW, Suite 820, Washington, DC 20005; 202-347-7834.

BESTNET (Binational English and Spanish Telecommunications Network) was created in 1985 by Dr. Beryl Bellman of California State University as a way to explore computer conferencing as an educational tool in the Southwestern United States and Mexico. Grants from Digital Equipment Corporation have enabled the exploration of conferencing as a tool in a wide range of disciplines. For information: Dr. Armando Arias, Dean, College of Arts and Sciences, Campus Box 117, Texas A&M University-Kingsville, TX 78363; 512-595-2761; aarias@bestsd.sdsu.edu.

COALITION FOR NETWORKED INFORMATION, formed by the Association for Research Libraries, CAUSE, and EDUCOM, promotes the creation of and access to information resources in networked environments. A CNI working group focuses on teaching and learning issues. For information: CNI, 21 Dupont Circle, Washington, DC 20036; 202-296-5098; e-mail joan@cni.org.

EDUCOM, a nonprofit consortium of colleges and universities headquartered in Washington, DC, sponsors the Educational Uses of Information Technology (EUIT) program (see details, p. 45).

INSTITUTE FOR ACADEMIC TECHNOLOGY, a partnership between IBM and the University of North Carolina, Chapel Hill, is a peer-to-peer resource for educators in discovering and sharing innovative ways to use computer technology to enhance learning. The IAT offers technology seminars, hands-on computer workshops, satellite broadcasts, and technology reports. For information: 919-560-5031; e-mail info.IAT@mhs.unc.edu.

INTERNATIONAL UNIVERSITY CONSORTIUM, a membership organization of universities on four continents, has developed media-based distance education materials for use by its member institutions and helps them prepare for the use of a variety of technologies in distance education. For information: John Strain, International University Consortium, University Boulevard at Adelphi Road, College Park, MD 20742; 301-985-7811.

LEAGUE FOR INNOVATION IN THE COMMUNITY COLLEGE, a nonprofit educational consortium of resourceful community colleges, annually hosts a conference on the application of computer technology to improve teaching and learning in community colleges. For information: League for Innovation, 26522 La Alameda, Suite 370, Mission Viejo, CA 92691; 714-367-2884.

LEARNING TECHNOLOGIES PROGRAM, sponsored by Cornell University and Apple Computer, Inc., has developed a series of workshops to help faculty integrate information technologies into the curriculum, and is currently disseminating methods and materials through a "train the trainer" program to help others offer the LTP curriculum. For information: Learning Technologies Program, CIT-220 CCC-Garden Avenue, Cornell University, Ithaca, NY 14853-2601; 607-255-3329; e-mail LTP@cornell.edu.

SUNY CENTER FOR LEARNING AND TECHNOLOGY provides consulting services in distance learning program design, development, and administration and in faculty training and support for SUNY and other higher ed institutions. For information: Carol Twigg, SUNY Empire State College, One Union Avenue, Saratoga Springs, NY 12866; 518-587-2100; e-mail ctwigg@nyescva.bitnet.

WESTERN COOPERATIVE FOR EDUCATIONAL TELECOMMUNICATIONS is a program of the Western Interstate Commission for Higher Education (WICHE), established to facilitate resource and information sharing in the use of telecommunications and other technologies for education. For information: Western Cooperative for Educational Telecommunications, PO Drawer P, Boulder, CO 80301-9752; 303-541-0231; mcgill_m@cubldr.colorado.edu.

NON-COMMERCIAL SOURCES OF ACADEMIC SOFTWARE

CONDUIT, University of Iowa, Iowa City, IA 52242; 319-335-4100; e-mail hirst@cs.uiowa.edu.

ISAAC (Information System for Advanced Academic Computing), MS-FC06, University of Washington, Seattle, WA 98195; 206-543-5604; e-mail ISAAC@uwae.egr.washington.edu.

TASL, North Carolina State University, Raleigh, NC 27695-8202; 919-737-2524; e-mail risley@ncsuphys.bitnet.

REFERENCE MATERIAL

Changing the Way We Teach and Learn: Interactive Multimedia, a video produced by the University of Melbourne, Australia, demonstrates effective applications of information technology to teaching and learning. Available to CAUSE members from the CAUSE Exchange Library for the cost of reproduction and handling; phone 303-449-4430; e-mail orders@CAUSE.colorado.edu.



Professional Paper Series

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by Robert C. Heterick, Jr.

Strategic planning for information systems, with a description of components needed to purvey an institution's information resources as though they were delivered from a single, integrated system. Funded by Digital Equipment Corporation. 22 pages. 1988. \$8 members, \$16 non-members.

#2 *Information Technology—Can It All Fit?*
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Three presentations from the Current Issues Forum at CAUSE88, where Paige Mulhollan, Wright State University President, advocated highly centralized management of information resources; Robert Scott, Vice President for Finance at Harvard University, discussed factors that led to a decentralized approach at Harvard; and Thomas W. West, Assistant Vice Chancellor for Computing and Communications Resources at The California State University System, explored alternative models. Funded by IBM Corporation. 17 pages. 1989. \$8 members, \$16 non-members.

#3 *An Information Technology Manager's Guide to Campus Phone Operations*
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and Judith V. Douglas

An overview of the chief information officer concept in higher education, including the results of a survey conducted by the authors in 1989. The authors provide an extensive literature review, including a discussion of industry surveys, and a bibliography of over 140 books and articles. Their survey results are included in the appendix. Funded by Deloitte & Touche. 42 pages. 1990. \$8 members, \$16 non-members.

#5 *Information Security in Higher Education*
by Raymond Elliott, Michael Young, Vincent Collins,
David Frawley, and M. Lewis Temares

Some of the key issues relating to information security on campus, based on in-depth interviews conducted by the authors at selected higher education institutions. Includes findings and observations about informa-

tion security awareness, policies, administration, control, issues and concerns, as well as risk assessment and the role of auditors and consultants in information security design, review, and testing. Funded by Coopers & Lybrand. 26 pages. 1991. \$8 members, \$16 non-members.

#6 *Open Access: A User Information System*
by Bernard W. Gleason

Design concepts and principles for a user information system providing open and easy access to information resources for administrators, faculty, and students, based on the author's experiences at Boston College. Addresses many of the organizational, managerial, social, and political forces and issues that are consequences of an open access strategy on campus. Funded by Apple Computer, Inc. 24 pages. 1991. \$8 members, \$16 non-members.

#7 *People and Process: Managing the Human Side of Information Technology Application*
by Jan A. Baltzer

An examination of the management structures and approaches that can make the application of new technology successful. Focuses on research and writings of management and communication professionals on organizational culture, managing change, end-user focus, attention to detail, and the importance of "fun." The author shares experiences of the Maricopa Community Colleges in these processes. Funded by Digital Equipment Corporation. 30 pages. 1991. \$8 members, \$16 non-members.

#8 *Sustaining Excellence in the 21st Century: A Vision and Strategies for College and University Administration*
by Richard N. Katz and Richard P. West

A discussion of a "network organization" vision which the authors see as a necessary response of colleges and universities to challenges of the 1990s. Strategies set forth in this paper support an information-intensive modern higher education institution, requiring increasingly sophisticated leadership and an administrative infrastructure which is optimized for service, speed, quality, and productivity. Funded by the IBM Corporation. 22 pages. 1992. \$8 members, \$16 non-members.

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by James I. Penrod and Michael G. Dolence

An overview of the principles and processes of reengineering (transformation) to move higher education enterprises into the new information/service economy. Includes a review of philosophies already widely used in business, applications in higher education, and implications of reengineering for information technology units. Funded by Coopers & Lybrand. 32 pages. 1992. \$8 members, \$16 non-members.

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