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ABSTRACT

An in-depth look is presented at how institutions are currently planning for microcomputers. The question is not whether the computer network on campus and between campuses will be the single most important technological event of the century for higher education, but rather how it will occur. Six sections include: the coming of age of microcomputers: a growing challenge to planning in postsecondary education (profound change and challenge, environmental factors, and the purpose of this report); trends and issues (technology, management concerns, and government involvement); planning and use of microcomputers in postsecondary education: a national survey (policies for purchasing and using microcomputers, policymakers and decisionmakers, selection criteria for hardware and software, use of microcomputers, and financial and other commitments); planning process (muddling through, the reactive process, traditional long-range planning, environmental scanning, strategic planning, and tactical planning); examples of institutional planning (Brown University, Clarkson University, Drew University, Drexel University, University of Iowa, Lehigh University, Princeton University, and Stevens Institute of Technology); and conclusions and recommendations (a clear need, operating assumptions, recommendations, and judgments). Ten specific recommendations. include: use strategic planning as the most appropriate planning model; involve all faculty and staff in planning the institution's information system and build institutionwide support; and aim for synergy. One figure, 12 tables, and 77 references are included. (SM)

Planning for Microcomputers in Higher Education

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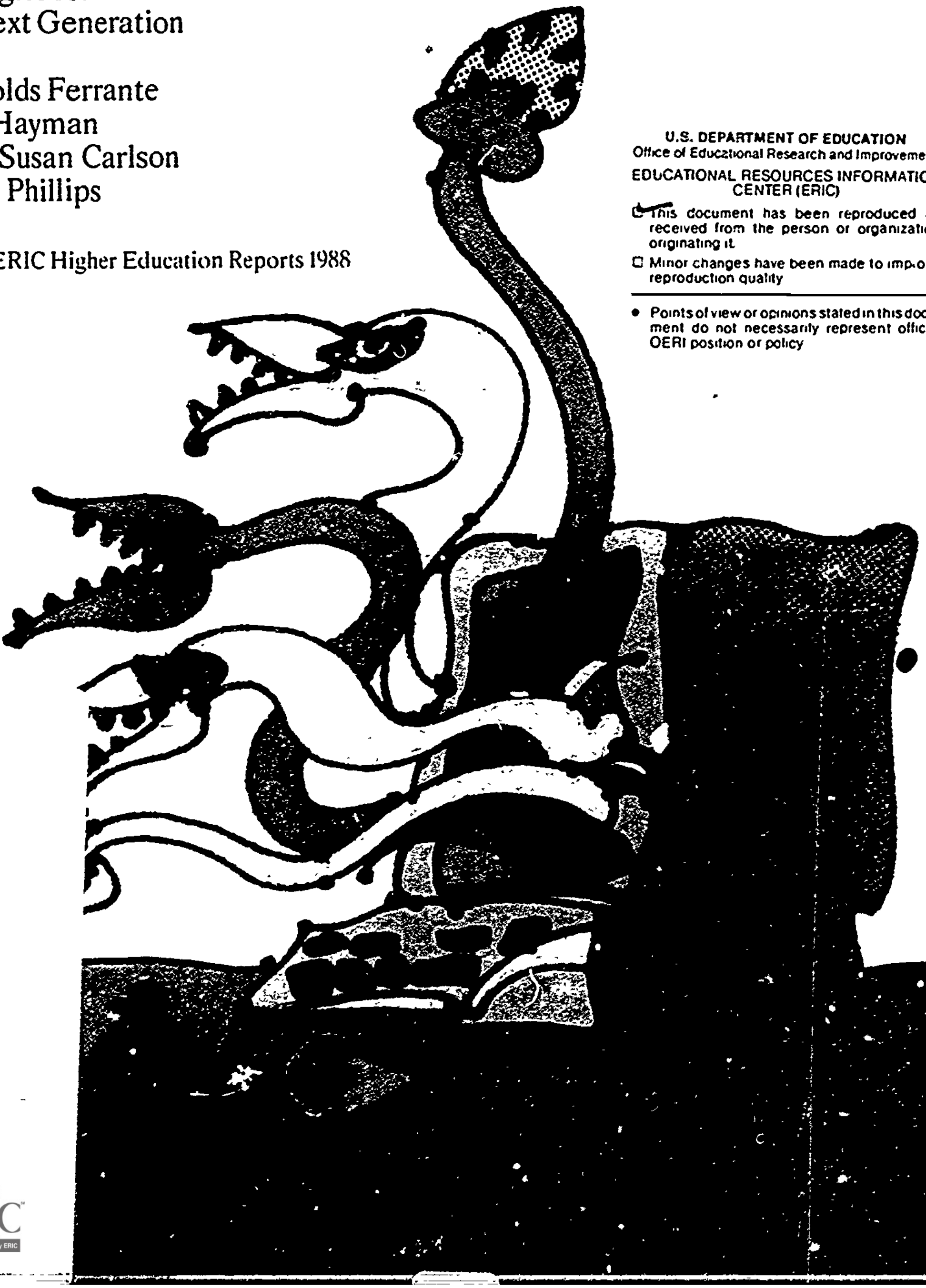
Strategies for the Next Generation

Reynolds Ferrante
John Hayman
Mary Susan Carlson
Harry Phillips

ASHE-ERIC Higher Education Reports 1988



Planning for Microcomputers in Higher Education:
Strategies for the Next Generation

by Reynolds Ferrante, John Hayman, Jr., Mary Susan Carlson, and Harry Phillips

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EXECUTIVE SUMMARY

The computer, one of the most important devices in the evolution of civilization, is itself undergoing a profound transformation. Mainframes and minicomputers are being replaced by microcomputers, whose power and speed now equal that of even the largest computers of a few years ago. Computer networks can connect not only diverse offices on a single campus, but also entire campuses to regional, state, national, and international groups with access to the growing universe of human knowledge. The question is not whether the computer network will be the single most important technological event of the century for higher education, but rather how it will occur. The larger, wealthy colleges and universities will be ready for the technology, but how should other institutions plan? The response to this question is the basis for this report.

What Trends Affect Colleges?

Trends in technology on campuses closely reflect societal trends. These trends are exemplified by instantaneous communication across campuses, decentralization of computer services, greater democratic participation in campus planning, horizontal networking, and self-education in learning new technology. Today's sophisticated hardware uses expert systems and supercomputers to push the limits of artificial intelligence and direct voice communication. The production of software has evolved from customized programming to the current thousands of microcomputer application programs for campuses. Instructional software is still in its infancy and will remain there until institutional incentives for faculty provide the considerable time required for development.

The most important recent development in the field is the computer network. Networks create the need for central administration, at the same time requiring decentralization of computer services over campuses. Networks are becoming the tools through which information is managed in colleges and universities. They also permit new academic and social groups to form across campuses, contributing to cross-disciplinary research and understanding. The time will come when computer networks will tie together all students, faculty, and administrators on campus and around the world.

Training for computing has emerged as a key factor in keeping faculty and students ahead of the technology. Financing new and innovative technology has required outside help from private foundations and government grants, because few institutions have the resources to purchase massive numbers of microcomputers. This condition is changing as the cost of financing is passed on to students. Government agencies play a pivotal role in supporting new developments and innovations.

What Trends Are Occurring in Planning and Using Microcomputers?

A recent national study examined how colleges are planning for and using microcomputers. Its findings are important in understanding current trends in planning. Most significant, very few colleges had institutionwide formal structured plans for the development of microcomputers. Most planning was carried out by committees, which is the dominant structure for selecting hardware and software.

Committees were involved in making decisions for planning twice as often as individuals or departments. The evolving practice is to hire a single administrator to coordinate the campus's total computing functions. Previously, students' use was the most important factor influencing policies and plans, followed by cost. Today, the greatest factor is maximizing general access to computing by all members of the university community.

The greatest use of software has been in word processing, solving math and statistical problems, business applications, educational applications, and programming. Today, computer courseware is needed to improve instruction; its absence is probably the biggest stumbling block to the continued expansion and use of microcomputers. Hardware is now selected for its capacity to be part of computer networks as well as its quality of technical support, warranty, keyboard functions, portability, ease of operation, telecommunications, and service.

What Models and Processes Have Colleges and Universities Followed in Planning for Technology?

Many planning processes are used for the development of microcomputers in higher education, but institutions develop their own to meet special needs and requirements. Several planning processes seem to operate in an institution at the same time, ranging from "muddling through" and reactive planning to long-range and strategic planning with environmental scanning. In view of the problems and requirements created by microcomputers, strategic planning with environmental scanning is ideally suited to facilitate the planning process for technology.

Do Exemplary Planning Strategies Exist?

A growing number of colleges use elements of strategic planning with environmental scanning for development of microcomputers. Among these institutions, similarities occur in the planning strategies that are important fo. any institution:

- Formal, continuous planning
- The strengthening of missions and establishment of a niche in the field
- Campus networks, with plans for all faculty, students, and administrators eventually to be connected
- Centralization of authority with decentralization of services
- Consideration of external societal factors
- Commitment of considerable resources over an extended time.

How Can Colleges Keep Up to Date?

Most planning for microcomputers in higher education has not been effective, partly because technology has developed so fast. Existing planning mechanisms have not coped well with the changing technology. While everyone knows about microcomputers, few understand the challenge of its technology. The situation is serious and the need to improve planning compelling. What should colleges and universities do? Within the special culture of each college and university, the following strategies are recommended:

- Consider strategic planning with environmental scanning as an effective planning model for technology.
- Establish a central authority, at the level of vice president, to coordinate all planning and implementation of campuswide networks.
- House all responsibility for computing in a single unit and disseminate information to all members of the campus community.
- Involve all faculty and staff continually in planning the campus information system.
- Develop an organizational infrastructure that supports campuswide use of microcomputers and the broader use of networks.
- Integrate all curricula within the campuswide networks with the support of requisite instructional software.
- Secure every method possible for long-range financial sup-

port for development, including federal, state, private, and local sources.

- Train all users as a continuous, centralized function with a budgeted allocation of institutional resources.
- Make synergy the goal for campuswide networks to improve access to resources and universal use of information.
- Establish a detailed plan to develop and operate the system, to address users' needs, and to involve faculty and staff.

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FOREWORD

In many respects, the use of microcomputers within higher education is not dissimilar to the condition of the Biblical tower of Babel. No single voice, direction, standard, or planning process has emerged to produce a rational framework for integrating microcomputers into the institution. Higher education, because of its underlying values supporting decentralization, consensus building, and academic freedom, more so than any major organizational structure in the U.S., has created a confused morass concerning the use of microcomputers. Obviously what exacerbates this situation are the constant technological developments occurring in the microcomputer industry.

Some of the planning issues are fairly obvious. Decisions need to be made concerning specific equipment and the various types of programming or software to be provided; issues concerning networking and access to computer data base information need review, as do the overall concerns of cost, maintenance, and obsolescence. Less obvious concerns deal with personnel: Who should have and who must have access to computers? What type of accommodation should be made to idiosyncratic program needs? Do microcomputers supplement or replace other support services, such as secretarial support? All these issues can be summed up under one simple statement: How can a higher education institution make the most efficient and effective use of microcomputer technology in order to achieve its educational mission? The answer to this question cannot be answered in the usual atmosphere of academic anarchy. There must be some institution-wide rationale. This is the focus of this report.

This report, written by Reynolds Ferrante of The George Washington University, John Hayman Jr. of Troy State University, Mary Susan Carlson, and Harry Phillips of James Madison University, provides an in-depth look at how institutions currently are planning for microcomputers. The authors make ten specific recommendations that can be considered by colleges and universities wishing to improve upon their computer-purchasing strategies.

It's almost a cliche to say that the most significant new addition to higher education this second half of the 20th century has been the computer. Never has a new technology so greatly altered not only the teaching and learning aspects of an institution, but also its administrative capabilities. It is also true that there is no other single utilization of a technology that could make one institution more competitive or distinctive from another. Adequate planning for microcomputers is absolutely necessary if institutions are to be prepared to educate their students to meet the challenges of the 21st century.

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This monograph is dedicated to the late Dr. Robert Sweitzer, professor emeritus of higher education at Pennsylvania State University.

This report was sponsored by a grant from Epson America, Inc. The project, which began three years ago, carried out a national survey of institutions concerned with planning for the development of microcomputers. The results of the survey have been brought up to date with recent literature and case examples of institutional planning.

We are grateful to Elaine Haddock, associate in research, for her efforts since the inception of the study; Dr. Carol Hoare, George Washington University, for the original development of the monograph; Dr. Janet Novotny for her assistance in reviewing the monograph when it needed a fresh point of view; Mary Louise Ortenzo for editing the initial draft; Dr. James Morrison for reviewing the planning sections; and Leslie Prokop and Barry Prokop for their final review.

A special debt of gratitude is owed to Ed Harris, president of Persoft, Inc., and David Haskin, product manager, for the use of "IZE" software to facilitate the preparation of the literature review. As a result of its use, the research time required to prepare the monograph was greatly reduced.

THE COMING OF AGE OF MICROCOMPUTERS: A Growing Challenge to Planning in Postsecondary Education

Profound Change and Profound Challenge

The nerve systems and the decision mechanisms of the institutions will be modified, and its behavior will be forever different.

Observers have noted for some time that society is moving into the information age or the age of technology, a move that is accompanied by rapid change, instability, and general feelings of insecurity and isolation. Higher education has been hard-pressed to keep abreast of changing needs, and its planning mechanisms have been severely strained as they attempt to create a meaningful future.

What are the trends that so strategically affect higher education? The most important ones are that (1) technology will have an increasingly greater impact on teaching and learning, (2) administrative practices will become more efficient as traditional enrollment decreases, (3) alliances between higher education and the business and industrial sectors will continue to grow, (4) advances in hardware and software will compound their implementation, (5) users' sophistication will require entirely new technical services, and (6) legal and ethical problems will demand new attention (Penrod and Dolence 1987).

Now the situation is worsening as one of the chief instruments driving change, the computer, is itself undergoing a profound transformation, and the "emerging second generation of information systems [is] radically different from the first" (Zachmann 1987, p. 6). The first generation was dominated by proprietary mainframes and minicomputers with centralized processing and centralized power and control. The emerging second generation will be dominated by microcomputers and characterized by distributed resources and high-speed, fully connective peer-to-peer networks. The change is away from "monolithic back-office maintrames" to inexpensive microcomputers scattered throughout an organization and providing ready access to computing power (Verity and Lewis 1987). Key concepts in the new generation are "networking" and "connectivity."

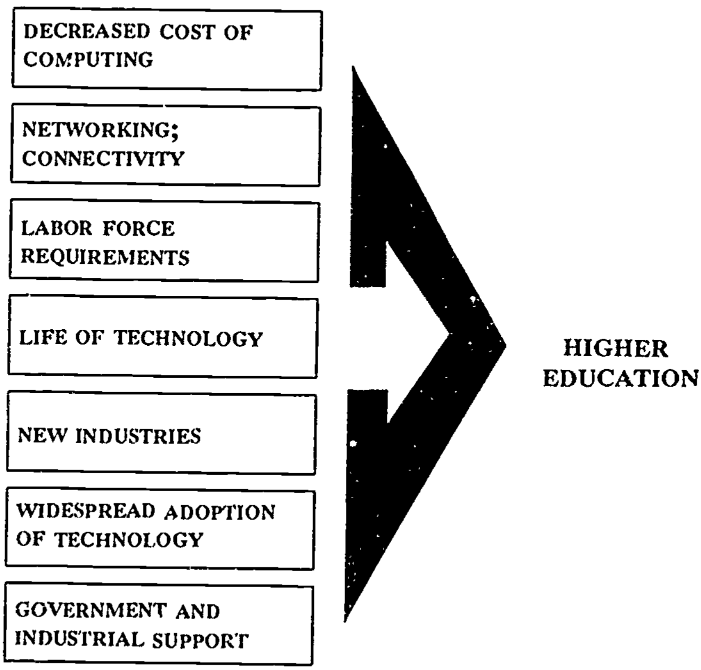
The impact of these changes on higher education is certain to be profound. New hardware must be selected within limited budgets. Curricula must be revised to match new job requirements. Faculty must develop new knowledge and skills. Centralized mainframe and minicomputer operations must redefine their roles and redirect their behavior, a painful process after years of absolute control over computing.

But these changes reflect only a part of the larger problem—and perhaps not the most important part—for the impact will be systemic in nature. In effect, the nerve system and the decision mechanisms of the institution will be modified, and its behavior will be forever different. This is the change that higher education faces, and the challenge to planning is to help make the transition successful. Planning has seldom faced such a challenge.

Environmental Factors

A variety of external factors affect higher education today (figure 1). The fantastic development of computers over the past 40 years is one of the central events of our time. Costs per instruction executed have decreased by an order of over 1 million, while processing speeds and storage have increased on a similar scale. The microcomputer, considered at best a toy only 10 years ago, is one of the great success stories of technology.

FIGURE 1
ENVIRONMENTAL FACTORS AFFECTING HIGHER EDUCATION



IBM recently stated that its fastest microcomputer has the raw processing speed of a 1975 mainframe costing $3.5 million (Verity and Lewis 1987).

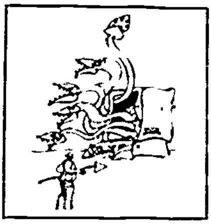
Communications technology has also made giant strides, and the combination of communications and computing is the basis for the move to the second generation of information systems. Aside from the microcomputers' raw processing power, connectivity in its broadest view is the key concept, which incorporates a systematic interconnection of an organization's dispersed information-processing assets, including hardware, systems software, user applications, and data bases. All of the resources associated with a computer network will appear to the user as a part of a single, integrated entity.

Technological advances significantly affect the labor force of the country. The Bureau of Labor Statistics indicates that between 1984 and 1995 16 million new jobs will be created (U.S. Department of Labor 1985) and that nine out of every ten jobs will be in service-producing industries. The three major occupational groups projected to account for the largest proportion of workers requiring postsecondary education are managers, professional workers, and technicians, all of whom will use computers in their work.

Other factors affect the economics of technology use:

- The most advanced and sophisticated technology has a short useful life because of the continuous development of new technology that will be more effective as a replacement. This replacement could occur as quickly as two or three years in the case of microcomputers, where an ongoing need to purchase more advanced equipment will expand the market for new products.
- Advancing technology creates new industries. Within these industries, new occupations, specializations, equipment, and services to society are generated, in turn creating new consumer use.
- As consumers and the general public learn more about the technology and adopt it for business and industry, they later adopt it for their own personal and home use. The final effect is an infusion into the general social fabric.

These changes, of course, affect education. The prospect of continued rapid change is altering the idea that education ends with a college degree. More and more, a four-year college edu-



cation is considered entry-level training in a series of long-term serial educational opportunities required to keep abreast of technology and function in the changing work force. Formalized lifelong learning is moving from an "option" to a "necessity" to respond to changes in society. Growth in knowledge and information requires constant reeducation, and in many fields, continuing education is essential.

A related issue is the place of education. Numerous data bases in the field today can be referenced from any place where communications are available. The availability of CD-ROM (compact disk read-only memory) video-disk technology and current development of multiple-write laser disk technology can provide easy access of entire university reference collections. With the capacity to do research outside the library and classrooms, institutions are changing their conception of where learning should take place.

Knowledge of computers is increasing rapidly among students first entering postsecondary education. The National Commission on Excellence in Education recommended that students should be able to understand the computer as an information, computation, and communication device; use the computer in other courses and for personal and other work-related purposes; and understand the magnitude of computers, electronics, and other related technologies.

The Office of Technology Assessment (OTA), the analytic arm of Congress, indicates that the federal government must take a much larger role than it has previously in the nation's technological development to achieve its full potential and meet societal requirements. It recommends that Congress develop a national futures initiative to pull together research nationwide, foster teacher training, and develop software (Solomon 1988). And President Bush's first presentation to a joint session of Congress outlined priorities in support of OTA's recommendations and the broader concerns of meeting the needs of a technological society.

Recent information indicates that elementary and secondary schools have made a substantial effort in the last five years to acquire and use microcomputers. Most authorities agree that elementary and secondary schools contain more than 1 million computers, a ratio of about 40 students to a single computer. By the next decade, that ratio will be 15 to 1, and the likelihood of every student's becoming computer competent will be considerably increased. In addition, about 10 million personal computers are currently located in homes in the United States, and estimates are that 40 percent of those homes have school-age children.

Microcomputers have already influenced postsecondary education heavily. More students are entering college with basic skills in computer literacy. Faculty are becoming more interested in applying technology within the classroom and in attending workshops to "retool" personal skills related to computer applications. Textbook publishers are developing software compatible with course content or standard curriculum textbooks.

In 1983, a description of the campus computing environment of the future summarized the viewpoints about probable trends. Many of them have already been realized.

- More students each year demanding courses and seminars in information-processing fields;
- Rapid growth in computer applications in new areas relative to the costs that shift rapidly;
- A decentralization of computing resources on campuses accompanying the rapid development and spread of microcomputers;
- Nationwide discipline-based computer networks;
- Larger capital investments needed to compensate for the current inadequate level of funding for instructional computing;
- A need for new relationships among higher education, government, foundations, and industry to generate the required human, technological, and financial resources (McCredie 1983).

Widespread computing will become a reality throughout higher education (Gilbert and Green 1986). Personal computers with word processing software will be so inexpensive that purchasing such a system can be justified by the word processing power alone. In the past, innovations in institutional computing were often supplemented by grants and federal government support. They will decrease with administrative budget cuts, and colleges will find other ways to support their development. Rather than allocate costs to computing centers or departments, they will be budgeted throughout the institution, supported in part through tuition or fees.

The U.S. student population is also changing. The average number of students 18 to 24 years old is declining, but the decline is offset in part by an increasing number of adults enrolling as part-time students. Nevertheless, competition for students is increasing. Those institutions that have distinctive programs, low tuition, or significant support for tuition and expenses will be able to compete for students. Graduate schools will shift full-time programs to part-time programs to allow older students to attend school in the evening for lifelong learning and second career programs.

Society is well into the age of information, and the effects are already profound. Computing and rapid communications have become an integral part of the culture, and they are changing the nature of the work force, which in turn changes the needed curricula and the characteristics of the consumer of higher education. The computer has become institutionalized within society. Computer competence is rapidly becoming a characteristic of the entering college freshman. Now, in addition is the move into networking and to information systems that bring the full power of the computer to every person. Indications are that change will continue at its current rapid pace well beyond the turn of the century, and then advances in areas like artificial intelligence will bring new triumphs and new challenges. Higher education needs urgently to control its computing future rather than to be controlled by it.

The Purpose of This Report

Within this context of society, this monograph addresses trends and issues in planning for the use of microcomputers in higher education and planning for changes that will result from their use. Its major purposes are to increase the understanding of and to improve the capacity to plan for microcomputers in institutions that have *not* been intensively so involved previously.

This monograph is intended to help colleges and universities plan more effectively for use of microcomputers and the impact of microcomputer technology. Five main sections follow this introduction. The second section is concerned with the trends and issues affecting the planning for development of microcomputers. The third section reports the results of a national survey on planning for and using microcomputers prepared specifically for this monograph and summarizes changes occurring in the field since the survey was conducted. The fourth section presents a series of planning processes used for development of microcomputers in higher education, the fifth presents examples of institutional planning and its relationship to those processes, and the final one presents conclusions and recommendations for planners.

Only a few years ago, colleges and universities resisted micro computers because they were viewed as unperfected technology and, some feared, would inhibit social interaction and interper sonal communication. Neither did the administrators of main-frames in the computer science departments of universities and colleges readily accept the first microcomputers. The prevalent attitude clearly reflected then in institutional planning was that they were toys that would never replace the mainframes. Some of this resistance has continued, but it has been reduced dramatically by the need for a work force trained in the use of microcomputers (Buday 1987).

The prevalent attitude clearly reflected then in institutional planning was that [microcomputers] were toys that would never replace the mainframes.

Given the profound advances in computer hardware and soft ware, problems related to computer literacy and equity may be resolved as campus planners provide universal access to vast sources of information. Planning strategies will include (1) more centralized coordination of all computing sources across the disciplines, (2) automation of libraries, (3) formation of comprehensive integrated hardware/software networks by connecting many different types of computers, (4) integration of computers into the curriculum, particularly in subjects that have traditionally steered away from automation, and (5) development of more powerful application and instructional software. These strategies will become increasingly more complex and difficult for planners to manage.

This section focuses on important trends and issues in technology, management, and government that affect higher education and that can provide an emerging perspective of computing in academe.

Technology

Societal trends

Interrelated with advancements in technology, societal trends reflect the higher education computing field. *Megatrends*, nearly a decade old now, identified five such trends that would influence the future: instantaneous communication, decentralization, participative democracy, horizontal networking, and self-help.

1. *Instantaneous communication*. High-speed electronic mail and computer networking for communication are a growing part of many campus networks. Transmission and exchange of information are almost instantaneous.
2. *Decentralization*. The move from centralization to decen-

tralization is evident in campus systems where microcomputers operate in distributed networking environments. The networks are connected to central systems.

3. *Participative democracy*. The participative committee structure on campuses is growing to include decisions on functions and uses of microcomputers. The committees formulate plans, decide on allocation of resources, monitor development, and evaluate effectiveness of the systems.
4. *Horizontal networking*. Administrative hierarchies are moving toward horizontal networking, and distributed data and information networks are growing through connected systems. This trend will continue until most campuses have maximized the stand-alone power of microcomputers.
5. *Self-help*. The continuous change in technology has caused students and faculty to be self-directive. Self-instruction has become the common process for many users in higher education learning about computers (Naisbitt 1982).

Other trends also result from advances in campuswide long-range computer planning, as institutions have moved from informal reactive processes to formal planning models. As a key part of a formal planning process, for example, Cal State identified several trends that would affect its future. These trends have broad application for other institutions concerned with planning for computing. Among the 19 trends identified, eight were considered the most important:

- *Information technology will increasingly impact curricula and the teaching-learning processes.*
- *Decreases in traditional enrollments and funding for education will result in a need for more effective administrative processes and productivity.*
- *Rapidly advancing technologies are fostering increased linkages between universities and industry.*
- *Hardware capacity will continue to grow, allowing software developers to make available increasingly powerful software tools.*
- *The rates of change in hardware and software, and the advent of converting technologies, will require continued institutional attention.*

- *Growing numbers of increasingly sophisticated users will necessitate expanded technical and consultative support.*
- *Ethical and legal issues regarding the uses of information technology will demand increasing institutional attention.*
- *The continuing impact of the divestiture of AT&T will result in incremental increases in telecommunications costs* (.rod and Dolence 1987, pp. 15–16).

Evolution of hardware

Society will continue to require technology that satisfies business and industrial needs, and, despite the cost, higher education will adopt new technologies to meet emerging requirements of the work force. Changes in that technology have been dramatic. First-generation computers used vacuum tubes, which were replaced by transistors and then by integrated circuits on silicon chips. Each generation increases in power and capacity. The new fifth-generation computer will use expert systems that significantly increase the effectiveness and efficiency of both production and artificial intelligence.

Since the days of 32K and 64K machines (32,000 and 64,000 bytes of information) with limited mass storage in the 1960s, personal computers have moved to a standard of 1 megabyte random-access memory (1 million bytes of information) and 40-megabyte mass storage. Campus computer workstations in the near future should include a UNIX operating system, the ability to run several programs simultaneously (multitasking), 1 megabyte or more of memory, a 1 million-character screen, connection to a computer network and peripherals, the ability to support numerous operating systems, and user-friendly features—all in a system inexpensive enough for students' use that fits on the top of a desk (Shalvoy 1987).

Some computers are already approaching these needs. With many of these characteristics evident in the Macintosh II, Carnegie Mellon and other institutions are heralding its performance as the workstation computer of the 1990s. Steve Jobs's NeXT computer was purposely designed to serve the university community, based on needs identified in interviews of key people in academe and configured to meet the needs of the broadest segment of the university community (Thompson and Baran 1988).

To answer the question of what the computer of the year 2000 will look like, faculty and students at the University of Illinois prepared a paper describing their vision of the computer for the year 2000, which they named TABLET. Among its characteristics, it is the size of a notebook, battery powered, lightweight, portable, and touch-sensitive (no keyboard), and it features microprocessors geared to specialized tasks, a large memory, a removable disk of vast memory (1 gigabyte), input/output to peripherals, and interface with users through a stylus (to w on the face of the computer) (Fastie 1988). The closest device to the TABLET computer is the emerging laptop computer, which is just now beginning to pervade the higher education community because of cost, size, portability, and power (Ohler 1987).

Development of software

In the past, much of the software was developed for mainframes by programmers using the computer languages ASSEMBLER, FORTRAN, COBOL, and BASIC. With the advent of microcomputers, however, "hackers" and interested nonprofessional programmers could write their own computer applications. Business interest, of course, is booming. In addition, many nonprofessional developers are significantly contributing to freeware (freely distributed software) and shareware (low-cost or free software shared under agreement with the authors) libraries nationally. Commercially, Lotus, Microsoft, and Ashton-Tate alone have now sold almost $1 billion of software for microcomputers. The rapid shift in the last few years to courseware that enhances instruction also has implications for planners as site licensing and educational or bulk discounts become more important.

Although students and faculty successfully use many of the commercial products as well as freeware and shareware to facilitate academic work, the unmet need has been for software developed by faculty. Only recently have colleges and universities begun to encourage and support the development of instructional software—or to consider authorship of software when reviewing faculty credentials for decisions about promotion or tenure. Support for this development has come from a variety of sources: national computer organizations (for example, the EDUCOM Software Initiative), state consortia for development of software, dissemination grants from corporations like NeXT, alliances of business and higher education, such as that between IBM and Carnegie-Mellon, and federally funded projects from the National Science Foundation and Department of Education (*T.H.E. Journal* 1989). Academic partnerships with corporations also provide institutions with state-of-the-art software for instruction and research. The Higher Education Software Consortium makes available a selection of $2 million worth of software for mainframes and minicomputers for relatively small fees (*PR Newswire* 1988). Such initiatives are likely to expand to meet new demands for all types of software products.

Evidence of increased use of technology is everywhere in higher education. So how is this technology managed and how will it influence planning in higher education? These questions are the themes of the following topics on management.

Management Concerns

Management concerns in planning for microcomputers include technology, personnel, legal, and administrative issues.

Networking

General outlook. The need for faculty to become part of campuswide communication networks is fast becoming an essential part of institutional planning, but widespread implementation will lag until resources and technology can accelerate the process. New academic and social groups develop across campuses as a result of electronic mail and communication networks, contributing to cross-disciplinary understanding. Networking can make virtually all information accessible for both academic and administrative functions. The networks of the future will coordinate data bases from many disciplines and will ultimately bring together people in an information infrastructure.

It will soon be commonplace for scholars in any country to use satellite information networks to solve mutual national problems. One group supporting this development is EDUCOM's Task Force on Networking and Telecommunications, which is attempting to develop a national and ultimately international higher education network for the exchange of information (Revenaugh 1988). Similarly, BITNET, the six-year-old national intercampus computer link for more than 300 institutions that provides electronic mail and timesharing, plans to improve and expand its services as a stepping-stone toward national and international connection of all academic networks (Mace 1987b).

One of the most significant technical issues on university campuses today is "connectivity"—the networked linking of varied and disparate computing resources to provide services for faculty, students, and staff. The increasing number of intensively networked campuses like Carnegie-Mellon and Brown is a noticeable trend in the field. International Data Corporation estimates that in 1986 some 35,000 networks were installed in education, a number projected to have doubled by the end of 1987 (McCarthy 1988).

Campus networks. Campus networking requires a significant institutional commitment and a significant share of total institutional resources. Not surprisingly, the large and well-endowed institutions often have the requisite resources to fund campuswide networks and are the first to implement them. The University of Maryland indicated that the projected cost of expanding its facilities, a large part of which will be devoted to a campuswide computer network, could be as much as $25 million (Smith 1988). Smaller institutions with fewer resources will take considerably longer to establish networked computer services, but they must develop such systems to compete with other schools.

A massive campus computing system has been developed within the University of Michigan, covering more than 18 square miles. The aim is to integrate some 30,000 potential workstations, including dormitory rooms, engineering department terminals, administrative mainframe connections, small local area networks (LANs), and faculty nodes for exchange of specialized scholarly information. It works through Northern Telecom and Bell Northern Research. When completed, this network will be one of the most complex in the United States (Buerger 1987). Elsewhere, research carried out by Carnegie-Mellon on a high-speed network will allow computer users to swap data files quickly, send messages, and run programs on computers at 10 different sites. This research may provide a model for high-speed data transfer over U.S. computer networks (Markoff 1988).

Regional/national networks. Other networks are government and state supported and cover broad geographic areas. THENET, the Texas Higher Education Network, is designed to support the collaboration of faculty researchers and students. Aimed at industrial development in Texas, it will link the 13 campuses of the University of Texas (Brown 1988). The University of Alaska Network (UCAN) links the University of Alaska's 10 campuses with the remainder of the state's educational system (Seguin 1988). Some institutions are spending large amounts of money to develop networks, often in close cooperation and with the support of computer companies (for example, IBM and the University of Michigan at Ann Arbor) (Desmond 1988).

On a wider scale, the National Science Foundation nationwide network (NSFNet) was introduced in July 1987. Designed for scholarly research and communication, it provides networking services for academic and industrial research communities, allowing researchers access to scholars anywhere in the nation (Watson, Calvert, and Collins 1987).

Networks are important to campus planners because they will enhance distance education, in which faculty and students will be able to access instructional programs from satellites, television, telecommunications, and data bases (Holt 1989). Networks can provide access to the vast libraries of data and programs in all subjects, effectively lowering users' costs while enormously increasing the productivity of students and faculty. A 1988 EDUCOM meeting proposed the idea that wide-area networks will play the key role in the development of computer technology and training of the nation's youth (Revenaugh 1988).

Clearly, networking is a planning issue for campus administrators. The technology is in place and expectations are rising among faculty and students. Colleges and universities, and individuals within them, can no longer work alone but must connect to local, regional, and national networks.

Equity

Issues of equity are multiple. Institutions have problems in computer equity, the fair and equitable dispersion and use of computer resources throughout all segments of the academic community. Campus networks can help solve that problem. A related issue is that of access across campus (Gilbert and Green 1986). Departments and academic units like engineering, computer science, and business often negotiate directly with computer manufacturers for loans of equipment and grants. Although these departments previously received most of the computer resources, computer manufacturers are now realizing the opportunities for future sales in nontraditional computer disciplines.

Other issues involving equity are external. One exists between institutions, particularly research institutions versus nonresearch institutions: Computer manufacturers favor the large public and elite private institutions for gifts of equipment and development grants. Another results from state regulations that have prevented or restricted colleges from negotiating major discounts with computer manufacturers.

Software

One of the most serious planning problems in higher education today is the underuse of computers as a result of the lack of application software and courseware. A trend has been to integrate software into the curriculum to improve academic research. Courseware can facilitate instruction, self-learning, and personal productivity (Shao, Rothfeder, and Angiolillo 1988), but this integration has just begun.

Faculty-developed courseware is far behind the development of ommercial software, partially because few incentives exist for faculty to prepare instructional software, considering its time-consuming nature and the limited number of universities willing to accept the development of courseware as fulfilling requirements for tenure (Shao, Rothfeder, and Angiolillo 1988). The limited financial return to faculty is another significant factor in view of the time and effort required to develop software. When courseware is developed on campus, a question also arises of faculty or institutional ownership—the issue of intellectual property rights. Courseware will continue to be developed to enhance instruction, but institutions will have to provide incentives like faculty release time and revenue sharing to encourage wider participation (Gilbert and Green 1986).

Another related issue is financial: Institutional budgets for purchasing hardware have exceeded these for purchasing software. And a survey of campus spending indicated that 67 percent of the schools responding would probably spend about the same amount for software as allotted in their previous budgets (Shalvoy and Dersipilski 1986).

Decentralization and coordination of services

In the last few years, a trend has emerged toward decentralization of computer systems. Large universities have little choice but to decentralize when serving thousands of faculty and students in separate departments and with multiple requirements over large campuses (Shurkin 1987).

The greater the decentralization of computer services, the greater the need for central administration to ensure effective coordination. Expansion of computer access and use will require new administrative approaches to planning and the coordination of all computing services for all disciplines. Formerly, the sciences dominated computer centers, receiving the most administrative attention and resources, but that situation will not continue. Most colleges need to coordinate computer services and require administrative structures to do so through distributed networks. Coordination will increase as courses require significantly more applications like word processing, graphics, and calculation.

Integration
A factor influencing integration of computer services across disciplines is the need for students' access to libraries and data bases. Students are developing skills and competencies in correlation, integration, and assimilation as a result of the availability of, access to, and analysis of information. The considerable time to locate information in libraries, to prepare charts and graphs, and to revise papers will decrease. Students will have the capacity to produce papers and transmit hem to anyone on campus or, for that matter, around the country or the world.

Specialization
Because of shifting requirements of the labor force, students are concerned about the job market and insist on specialized training that prepares them for it. They want courses specializing in management, economics, and computing. Recent specialized social science courses have required specific computer skills. The problem with specialized knowledge—that it contributes to a lack of integration with those subjects—is a concern for planners (Schmuckler 1987).

Standardization of hardware and software
The movement toward standardization of hardware and software, encouraged by consumers and fought vigorously by manufacturers in the past, will probably be partially achieved in the next few years. Even now. UNIX-based systems are in virtually every major computer science department in the country (Jonas 1988), and Apple and IBM have developed machines that can operate with UNIX (Bruder 1988; Chester 1987). UNIX could emerge in the future as the dominant operating system in colleges and universities.

Colleges and universities attempt to provide their students with the best hardware and software by purchasing them from a single manufacturer. Harvard, for example, recently announced a multimillion dollar purchase of Zenith Supersport 286 microcomputers for MBAs (Mace 1988). This practice can be risky, however, and problems can occur when depending on a single manufacturer. The continued trend toward standardization and the movement toward networking with standardized protocols will increase common developments among manufacturers and universal use in colleges and universities.

Improvement in productivity
Microcomputers are beginning to be recognized as tools of productivity. Microcomputers make it both faster and less expensive to carry out system design and programming for mainframes (Verity and Lewis 1987). While a need will continue for mainframes to manage large-scale data processing and to handle large volumes of closely related information, microcomputers and advanced workstations can more economically handle lesser functions like programming and design, particularly as they grow in power. This "downscaling" will greatly decrease the costs of development typically associated with mainframes.

Efficiency
Although microcomputers are widely used on most campuses, their use is still limited on some campuses. The most efficient use will include all faculty, students, and administrators networked to a campuswide computer system. The growth and pervasiveness of microcomputers will continue to the point where most students and faculty will have access to campus computing services through networked microcomputers, and planners must consider that everyone on campus is a potential user. This increased use will be fostered by an increase in computer-related courses, expansion of campus computer software libraries, access to information and instructional data bases to enhance and support instruction, and development of software.

The power of laptop and portable computers will increase as their cost decreases, and they will replace many of the current desk-top models. While clusters of microcomputers may need to be available for class assignments and requirements, telecommunications will decrease the need for concentrations of desktops. The new question for planners will be how to facilitate the high number of users accessing campus computer systems through telecommunications.

In the future, training will take on greater importance and require an increasing share of institutional budgets.

Participation in planning
Participation of all administrative and faculty groups in an institution will be a characteristic of planning in the future. In the past when the scientific disciplines used mainframes heavily, centralized planning and control were common and staffs of computer centers made most administrative decisions. With wider use of computers across disciplines and administrative departments, greater representation of users is necessary, and the broad knowledge of an institution and cooperation of all campus groups must be incorporated into the planning process (Cates 1987). Another factor that has encouraged greater representation and consensus by various campus groups is the inability of any one group or administration to unilaterally plan for the diverse needs and requirements of a vast array of users. A clear projection of future needs can only come from broad representation of faculty and administration (Penrod and Dolence 1987).

The committee will likely continue as the most common administrative unit used in planning for use of microcomputers. Because of changes in technology, planning committees should remain in place to implement plans, because they are aware of institutional needs and requirements. Networking—which can coordinate data bases, information about personnel, student registrations, scheduling, and research—requires centralized coordination and decision making, and the committee structure does so effectively. It also allows for the effective coordination and scheduling of competitive institutional resources, as administrative advisory and decision-making groups are often represented on planning committees. In addition, this structure can improve computer equity among the disciplines, because discussions on developments and proposed plans can be negotiated from the onset of planning.

The administration of computing service today is managed differently from the time when mainframes dominated campuses as the single source of computing power. Larger administrative staffs report to vice presidents and other high-level administrators responsible for campus computing. These staffs are part of central groups tied to development and coordinating committees, which oversee the management of campuswide systems.

Administration

In an effort to manage effectively the massive coordination of high-budget campus computing services, institutions are appointing high-level administrators with titles like provost or vice president for information resources management, information services, or management information systems. The titles designate responsibilities for coordinating campuswide central administration as a major function. More than 100 chief information administrators are affiliated with colleges and universities, and that number is growing (Fleit 1987) as the need for coordinating campuswide information systems, purchasing in volume to reduce institutional costs, and central planning becomes more important. Future administrative planners will be faced with managing larger and more centralized computing systems.

As information becomes integrated and readily accessible, administrators will be better able to manage institutional planning. Budgets will be prepared from actual and projected resources using sophisticated budgeting applications, and administrators will know where cutbacks can be made without threatening valuable institutional initiatives and projects. Projections will allow administrators to determine what courses can be eliminated in any semester, opening possibilities for rescheduling available space. Future administrations will access all institutional functions and have the capacity to manipulate that information to enhance planning decisions.

Training

Training has emerged as one of the most important functions of campus computing. It is now included in institutional designs to meet requirements for applications and programming. Most students require access to computers to meet course requirements, faculty use computing to carry out their research, and administrators use computers to carry out an increasing amount of institutional management. Coordinated training must be provided for these functions.

In the future, training will take on greater importance and require an increasing share of institutional budgets (Hobart, Octernaud, and Sytsma 1988). Planning issues will revolve around coordination, if not centralization, of training on most campuses, with a library or central facility housing documentation and materials for training. Training for campus computing will range from courses and seminars for computer literacy to postgraduate instruction for specialized research and development. Advances and use of new technology will intensify the need for continuing advanced training for proper integration into the curriculum (Cates 1987). Documentation for training, often available on video tapes or video disks, will be improved in the future and become more effective in keeping institutions up to date on new developments.

Training faculty for technology is difficult for institutions to manage. Training options change from one semester to the next. Computer literacy is constantly redefined, causing institutions to reassess faculty needs to provide effective training. As more faculty become interested in using computers, application software, and courseware, they need computer skills to develop instructional courseware. Training for courseware is a high priority on campuses.

The need for training is exacerbated by increased enrollments in computing classes. Institutions find that because salaries for instructors are less than they can receive in private industry, they lose qualified faculty and limit their capacity to respond to students' demands for advanced computing. The rewards offered by industry for professionals in the computer fields will cause the shortfall to continue. In response, colleges are developing cooperative programs with local industries to provide opportunities for research and development for faculty.

Computer literacy is now as important as the capacity to read and write. More and more students are entering higher education with a knowledge of microcomputers. The problem of computer literacy becomes more complex for institutional planners as collegiate training must vary according to students' previous background and experience. A shift is occurring from basic literacy to more selective training required for all students to be successful in their programs of study.

Instruction

While computers are now commonplace on campuses, attempts to use them effectively for instruction have not been noticeably successful. With the advent of advanced scholar workstations and simulation software, however, the use of computers for instruction will increase. Considerable support and encourage-ment exist for instructional software through college and university initiatives, computer manufacturers, computer organizations (EDUCOM Software Initiative), and the federal government.

Many developments in the field are aimed at improving teaching and learning. The Electronic University Network, a San Francisco marketer, has provided online undergraduate courses to some 7,000 students since 1984. Nova University offers several postgraduate degree programs through Tymnet (Kellner 1987). Students in French history use a computer courseware game to help them understand the role of landowners in 17th century France. Developing courseware efforts could revolutionize the use of advanced computing to facilitate instruction and learning (Pollack 1987). A few universities like Stanford and the University of California at Irvine have developed interactive instructional programs and courses that demand a student have a comprehensive mastery of a subject (Bork 1987).

Computer crime

Over the last several years, computer "viruses" have disrupted computing services in American universities and colleges. Virus programs have been around almost as long as computers, but they previously were not as pervasive or costly to higher education. Such programs are often written by hackers, jokesters, and malcontents who express deviant behavior through the destruction and disruption of campus and nationally networked computer systems.

The cost of the destruction of information on campuses is enormous in terms of the staff time required to remove the virus programs and recopy information files. In some cases, virus programs could take months to emerge and be corrected. Corporations, government agencies, and Congress have responded to the destruction created by the virus programs, and demands for increased security are universal. Legislation introduced by Representative Thomas McMillen (Maryland) and the proposed Computer Virus Act of 1989 would broaden the types of actions covered by existing legislation. Other suggestions include calls for an ethics code for all campus and network users and careful education of faculty and students on the repercussions of computer crime (Richards 1989).

Software piracy
Manufacturers spend millions each year developing commercial software for the higher education market, and higher education exceeds the business world in illegally copying commercially produced software. The problem lies in institutions' unwillingness to enforce ethical principles restricting the illegal copying of software. Faculty who copy programs without authorization from the manufacturers send a message to students that it is all right to take another's property and use it without payment, an attitude that hurts the production of commercial software.

The problem of piracy is complex, and reactions have been mixed. When manufacturers provide deep discounts on application software packages, they find that they are competing with their own dealers for sales. Publishers who find unauthorized copies of software can bring an injunction against the school to force it to stop the practice, but they cannot collect any punitive fines (Parker 1987). One solution to consider is a campus-wide agreement among faculty, administrators, and students that unauthorized copies of software are not allowed and their use will not be permitted.

Financing and purchasing
Two trends occurring in financing will strategically affect expansion of microcomputers. The first is the decreasing cost of hardware and software as the volume of users expands. The second is an increase in the total resources spent to upgrade technology. Even with few comprehensive guidelines or total institutional plans to determine how best computer resources should be spent, colleges and universities spent close to $4.5 billion in 1987 on computer-related technology (Fleit 1987). And nothing indicates that institutions are planning to spend any less, with or without carefully drawn and articulated plans. Institutional allocations for computing occupy a large, growing part of the total budget.

Institutional purchases for large procurements will continue to be an essential part of manufacturers' marketing and sales (*Computer Reseller News* 1987), a fact that planners should take into consideration. The University of Michigan, which has thousands of personal computers, has purchased as many as 800 units at one time from IBM (Trespasz and Greene 1987). IBM has provided for the direct institutional purchase of its machines at an average 40 percent volume discount in a 400-unit annual contract agreement. Apple Corporation has provided 40 to 45 percent discounts for a 700-unit annual purchase for institutions (Blum-Brashier 1987).

Institutional planners will negotiate multiple discounts with several manufacturers to provide hardware and software through site licensing for the lowest possible cost. They will be able to purchase equipment through long-term financial agreements under institutional control, time payments, loan or lease programs, or financial guarantees with banks or other lending organizations. In some cases, colleges will subsidize already discounted systems to provide hardware and software at prices within the reach of all students and faculty. The aim of the agreements and discounts is to maximize ownership and access for everyone. Long-term financial agreements with banks, foundations, and lending organizations can help.

Financing campus computer systems requires a long-term commitment of resources. Long-term capital investment supported through operational budgets, loans, grants, and gifts is essential for advancing technology. Few institutions can afford to develop a campuswide system with hardware, software, and services in less than a few years. Although many of the telecommunication services will be in place for campuswide communication and networking for institutions that hope to be competitive, a continuing outlay will be necessary for investment in new technology and replacement of outdated systems. The campus network with all its functions and services will continue to be one of the most costly investments any institution makes.

The major research universities have been effective in obtaining external funding through businesses, government, and foundations for projects to develop campus systems and for research needed to advance the field. IBM donated equipment, cash, and support totaling $112 million in 1985 to help institutions develop new technologies to advance the industry. Cooperative research projects conducted jointly by IBM and a host of universities accounted for more than $127 million. Apple donated approximately the same amount. Brown, Carnegie-Mellon, and MIT received approximately $75 million to undertake extensive research on the role of large-scale networks of workstations on their campuses (Barbour 1986). The success of the larger research universities will continue. New methods of financing will be developed, for example, alliances with business and industry where shared profits for research and sales are returned to the institution.

Research and development
Computer research and authoring programs will improve research and greatly shorten the time needed to carry it out. Professors will locate information and manipulate data for research in a few hours, compared to weeks or months, through online data bases like Medline and ERIC, vast computer banks like DIALOG, and programs like IZE (Persoft Corporation 1989). Communication among professors through telecommunication networks around the country and over the world will facilitate getting the latest information on research in any field. Tomorrow's application packages for word processing, data analysis, graphics, content analysis, and statistics will include total integration of data and information.

Some characteristics of future research will change the way faculty and students operate in institutions: (1) comprehensiveness, as all references and sources in a field will be readily available for examination at almost any location; (2) completeness, as sophisticated analysis programs will perform content analysis and evaluation; (3) visual improvements, as statistical and scientific packages can present data in a multitude of charts, graphs, and desktop publishing formats; (4) targeted dissemination to researchers working in the same field; and (5) user-friendly computer programs that will assess the researcher's capability, then frame the responses to the user's level of comprehension. Such software is under development now for the European Space Agency's Columbus space station for astronaut training (Lawren 1988).

Government Involvement
Government plays an important and complex role in stimulating technological developments in institutions of higher education. At the federal level, the National Science Foundation (NSF), National Aeronautics and Space Administration, and Departments of Commerce, Defense, Labor, Agriculture, and Education carry out projects to enhance and develop the advancement of technology and computing. During the last 10 years, NSF spent $150 million to $200 million on educational technology applications in mathematics and science alone. The Department of Defense spends approximately $208 million a year on research and development in education and training technologies, and other agencies similarly support the advancement of technology and computing (Solomon 1988).

Federal involvement can, however, also inhibit planning and implementation of technology through convoluted restrictions and procedures. What governmental efforts are concerns in planning for microcomputer technology, and what should institutions do to deal with them effectively?

Planning and developing new programs for a college no longer simply involve conceiving a program, hiring appropriate faculty, and offering courses. The task of planning for the extensive use of microcomputers in contemporary institutions may become very complex. Extensive use of microcomputers in an institution could involve a complex pattern of campus planning and coordination, followed by considerable interaction at the state level with several different agencies, and finally involvement and approvals from federal agencies.

The major areas of interest to public college planners will involve state government, as state educational and procurement agencies are the most probable offices where direction and assistance are obtained. Computer compatibility and procurement processes are two of the primary functions that need to be cleared with state agencies. State legislatures have for some time insisted that the purchasing of all equipment for public institutions be conducted through competitive bids. Ultimately this process culminates in filling an order by selected vendors and consequently may require several months between the time equipment is ordered and its delivery. Some states are able to expedite the process by developing continuing contractual arrangements (usually called purchasing schedules) with given vendors, thereby short-circuiting the time-consuming advertising and bidding procedures.

The second way in which state agencies and regulations may become involved in the acquisition of microcomputers has to do with the compatibility and standardization of equipment. Institutions experienced in computer use insist that all purchasing procedures for students, faculty, administration, and researchers be standardized to ensure maximum intrainstitutional computer communication. Some states are beginning to expand this policy to cover the entire state, thereby laying a foundation for a statewide network of compatible computers. Such constraints do not prohibit students' and faculty's distinctive and creative uses of microcomputers, however. Private institutions, even though they may not be required to comply with state regulations, may find that requirements for compatibility might also work to their advantage.

Local governments' regulations and standards of performance for installing and using microcomputers will not likely affect higher education institutions' plans, with the possible exception of telecommunications that would cause interference or otherwise infringe on the franchise rights of local cable systems or other electronic installations within the geographic area of the institution.

Possibilities may exist for computers installed in colleges to receive benefits like technical assistance, grants-in-aid, or cooperative use from governmental agencies, which in many instances have provided substantial assistance to colleges and universities in computer science. Large governmental installations have become big users of computer systems; therefore, the experience and sophistication of personnel associated with the computing centers of such installations may be of considerable service to educational institutions.

In some cases, cooperative agreements between governmental agencies and educational institutions may be worked out for mutual benefit. Personnel exchanges between colleges and universities and federal agencies can be arranged for a period of one year or longer. Such arrangements could greatly benefit an institution making a major effort to develop comprehensive computer services for its faculty and students.

Summary

Institutions of higher education are faced with new issues—massive purchases of equipment and materials, development of courseware, and computing networks. Today's planners must be aware of trends in technology to be able to incorporate myriad management concerns into a constantly changing environment affecting both faculty and government relations.

PLANNING AND USE OF MICROCOMPUTERS IN POSTSECONDARY EDUCATION: A National Survey

The effects of the information revolution are ubiquitous. A university librarian reports that "there is no function in the library that has not been profoundly touched by electronic technology" (Ritcheson 1988, p. 22), and other components of the institution are experiencing the impact. Appropriate planning procedures and other response mechanisms should be in place throughout higher education—but to what extent are they?

Responses to these questions gave the general impression of planning processes designed for slower, more deliberate, and more orderly change being overrun by the onrush of events.

To answer that question, a study team at George Washington University in 1986 investigated the adequacy of current planning. After initially examining the literature and analyzing the results of site visits, the team conducted a telephone survey of selected colleges and universities. The field is changing so rapidly, however, that measurements taken at one time cannot be assumed to be accurate only a year or two later. Many of the survey results can best be seen as data points that help to clarify trends, and they are so treated in the following discussion. Information from current literature is used in many cases to update and to define more precisely the issues that are faced.

The survey was designed to answer several questions:

1. To what extent do different postsecondary education institutions have policies or plans related to microcomputers? What planning processes are being used?
2. Who actually makes decisions regarding the purchase and use of microcomputers? Who is involved in developing plans and policies? Who makes decisions to purchase and use microcomputers for schools, departments, and individual faculty?
3. What are the criteria for selection of microcomputers and related equipment? What do plans and policies indicate, and what is actually being used in schools and departments?
4. How are microcomputers actually being used by students, administrators, faculty, and others? How does the actual use compare to what existing policies and plans indicate is intended?
5. What commitments, financial and otherwise, have postsecondary institutions made to plan for, purchase, and use microcomputers?

The survey was designed to provide data generalizable to two groups in U.S. academic postsecondary institutions. First were individuals with prime responsibility for making institutionwide decisions about the purchase and use of computers, the "chief decision makers" who can presumably identify official policies and guidelines and planning procedures. The second group included representative administrators and faculty who could indicate which computer applications actually occur and could help clarify the discrepancy between intended and actual uses, between stated and implemented policy.

The sample was selected in two stages. First, institutions were stratified into three groups—public four-year institutions, private four-year institutions, and two-year institutions—and a purely random sample of 30 institutions from each stratum was chosen. The researchers identified (and included) the chief decision maker at each institution by calling the president's office. In the second stage, four faculty members and four administrators from each institution were selected at random, resulting in a sample size of 810 (see table 1). A surprisingly high completion rate, approximately 95 percent, was attained and, with replacements, 810 interviews conducted.

Persons identified as chief decision makers represented a range of positions (see table 2), with most in charge of general computing services or of academic computing. Within the sampling error, this table identifies persons in charge of decisions affecting purchase and use of computers in academic postsecondary institutions in April 1986.

The distribution of faculty/administrator respondents, according to academic affiliation, is shown in table 3. Based on this random sample of all faculty and administrators in postsecondary institutions, the largest group of the respondents, nearly a quarter, came from administration.

TABLE 1

UNITS IN SAMPLING PLAN

Type of Institution	Institutions in First Stage	Decision Makers	Faculty/ Staff	Total
Four-year public	30	30	240	270
Four-year private	30	30	240	270
Two-year	30	30	240	270
Total		90	720	810

TABLE 2

POSITIONS OF CHIEF DECISION MAKERS

N = 90

	Percent of Sample
Dean	2.2
Department chair	6.7
Director of institutional research	2.2
Director of management information systems	2.2
Director of computer services or center	51.2
Director of academic computing	13.4
Faculty member	3.3
Head of business office	4.4
President	1.1
Vice president for academic affairs	3.3
Other	10.0
Total	**100.0**

TABLE 3

ACADEMIC AFFILIATIONS OF FACULTY/ ADMINISTRATOR RESPONDENTS

N = 720

	Percent of Sample
Administration—no academic department	23.0
Architecture/design	0.8
Business/management	11.0
Communications/information science	8.3
Computer science	1.7
Education	15.5
Engineering	2.2
Health sciences	2.0
Humanities	11.1
Physical sciences	11.8
Social sciences	7.0
Theology	2.0
No answer recorded	3.6
Total	**100.0**

Policies for Purchasing and Using Microcomputers

The chief decision makers were asked whether an institution-wide policy or plan for microcomputers existed and if so its specifics. Their answers are summarized in table 4.

Nearly 68 percent of the institutions participating in the sur-

TABLE 4
INSTITUTIONS WITH POLICY OR PLAN

Institution Has a Plan	Public 4-Year $N=30$	Private 4-Year $N=30$	2-Year $N=30$	Total $N=90$
Yes	83.3%	73.3%	46.7%	67.8%
No	16.7	26.7	50.0	31.1
Don't know	0.0	0.0	3.3	1.1
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**

vey indicated that they had an institutionwide plan for use of microcomputers. On further questioning, it turned out that very few had a "formal structured plan," that is, a document sanctioned institutionwide by top administrators. Responses to these questions gave the general impression of planning processes designed for slower, more deliberate, and more orderly change being overrun by the onrush of events. The characterization of a "revolution sweeping higher education" (Coughlin 1987) seems applicable, as does the observation of computer administrators cleaving to the status quo "even after the status is no longer quo" (Shurkin 1987, p. 180).

A striking feature shown on table 4 is the difference among types of institutions. Some 83.3 percent of public four-year schools report having plans of some type. Private four-year schools, at 73.3 percent, are fairly close behind, but two-year colleges lag badly, with only 46.7 percent.

Policy Makers and Decision Makers

Institutionwide decisions

The 61 chief decision makers who indicated that their institution had an institutionwide plan or policy were asked who specifically was involved in drawing up the plan or policy. About 69 percent of the total indicated that the work had been done by a committee. If the institution did not have a computer committee, planning strategies tended to be developed by such persons as the director of the budget office, the president, the vice president for business affairs, or the provost. A wide range of positions was reported as being involved on committees. Regular faculty members were reported most often, followed closely by persons responsible for campuswide computer services. Persons who work directly with computers in their jobs were mentioned about 30 percent of the time, those in administrative positions about 43 percent of the time. A study conducted in 1985 by the Corporation for Public Broadcasting (the Higher Education Utilization Study) reported that, at that time, the institution's administrative officer most often made decisions about the acquisition of hardware (Riccobono 1986).

In the short time since the survey, a rapid move has occurred toward campuswide networking, integration of all computing facilities, and distribution of computing power, leading to the move toward a single administrative officer with institutionwide authority for information technology (Coughlin 1987). Stanford, for example, has a vice provost in charge of an information resources office, which covers both academic and administrative computing and includes sections concerned with instruction, networking, and libraries (Shurkin 1987). The University of Michigan has a vice provost for information technology in charge of campuswide networking (Mace 1987c). California State University at Los Angeles reorganized several existing units and created the position of vice president for information resources management (Penrod and Dolence 1987).

Factors influencing decisions
Respondents were asked about the importance of different factors in influencing the plan; table 5 shows the results, with ratings varying from 5 for very influential to 1 for not at all influential. Students' use was by far the most influential factor. Cost was second, followed in order by departmental use, institutional use, and individual faculty use. Agreement was greatest with regard to students' use.

The study team selected the factors in table 5 as a result of a literature review in late 1985. The factors suggest a forced

TABLE 5

INFLUENCE OF DIFFERENT FACTORS ON THE POLICY OR PLAN

	Average Score
Cost	4.03
Students' use	4.45
Departmental use	3.59
Individual faculty use	3.20
Institutional use	3.47

choice among individual users resulting from mutually exclusive categories of uses. In comparison, the chief topics of concern at EDUCOM's 1987 conference were reported as networking, automation of libraries, and software (Revenaugh 1988). While these concerns do not conflict with the factors in table 5, they suggest a shift to a more holistic conception. Instead of choices among individual users, the interest is more in general access to resources among all members of the higher education community.

Responsibility for implementation

Where an institutionwide plan existed, respondents were asked who was responsible for implementing it. The computer committee (16 percent), director of computer services or the computer center (28 percent), and faculty (13 percent) were mentioned most often as directly responsible. The trend toward movement to a single administrative officer with institutionwide authority has already been mentioned. Eighty-three percent of the respondents said that students had no involvement in the plan's development or implementation, a surprising result, given that students' use was mentioned as the most influential factor in developing a plan.

Decisions by schools and departments

The 720 faculty and administrative respondents were asked whether their school or department currently used microcomputers; slightly more than 80 percent responded positively. The 80 percent using microcomputers were asked who made the decisions on purchasing hardware and software (see table 6).

Department and school committees were involved in making

TABLE 6

DECISION MAKERS WITH REGARD TO HARDWARE AND SOFTWARE FOR DEPARTMENTS AND SCHOOLS

N=578

Decision Made By	Hardware	Software
Committee	50.4%	47.4%
Department	16.8	19.2
Individual	18.0	19.2
Other	1.0	0.0
Don't know	13.8	14.2
Total	**100.0%**	**100.0%**

decisions about hardware and software about twice as often as individuals or departments acting as units. Of those who made individual decisions, about 21 percent were deans and comptrollers, 16 percent were department heads, 15 percent were directors of the computer center, and 12 percent were faculty members. Six presidents made unilateral decisions on purchasing microcomputers.

The majority of the participants in the survey were involved directly (34 percent) or indirectly (23 percent) in the decision to purchase hardware and software. Respondents indicated that in future decisions on hardware and software they expected the committee structure to be dominant.

Selection Criteria for Hardware and Software

Institutionwide decisions

Respondents were also presented with a set of 19 criteria that might be used in selecting microcomputers and were asked to indicate the importance of each criterion in the actual selection. The rating scales varied from 5 for very important to 1 for not at all important. Results are given in table 7.

The most important single criterion for decision makers was the availability of software. Also very important were the operating system, compatibility with other machines, product reliability, price, manufacturer's reputation, and ease of operation. Appearance, size, and portability were judged least important. The greatest disagreement occurred on local area networking, followed by warranty, telecommunications capability, availability of service, and quality of technical support. Local area networking and telecommunications both had relatively low average scale scores.

Decisions by schools and departments

The question of criteria used in the past in selecting microcomputers was also posed to the sample of faculty and administrators; in addition, this group was asked what criteria they expected to be important in the future. Results are summarized in table 7.

The criteria considered most important in past decisions by faculty and administrators were similar in most cases to those of the chief decision makers. The most important was availability of software, followed closely by product reliability, the choice of an operating system, and ease of operation. Also high were the manufacturer's reputation, availability of service,

TABLE 7

COMPARISON OF PAST AND FUTURE CRITERIA IN SELECTING A MICROCOMPUTER SYSTEM

Criterion	Faculty/Administrators Past Average Score	SD	Faculty/Administrators Future Average Score	SD	Decision Makers Average Score	SD
Appearance	1.65	0.91	1.85	1.02	1.48	0.73
Size	2.50	1.24	2.88	1.23	1.81	0.83
Portability	2.72	1.26	3.09	1.30	1.86	1.06
Ease of operation	4.42	0.81	4.60	0.68	4.00	0.96
Operating system	1.46	0.77	4.38	0.88	4.26	0.96
Compatibility with other machines	4.21	1.16	4.42	0.94	4.27	1.16
Capacity of random-access memory	4.13	0.90	4.24	0.90	3.66	0.96
Local area networking	3.10	1.39	3.55	1.24	2.96	1.46
Keyboard functions	3.71	1.10	4.12	0.99	3.18	1.23
Graphics	3.27	1.22	3.52	1.37	3.43	0.95
Telecommunications capability	2.87	1.38	3.18	1.35	3.09	1.37
State-of-the-art product	3.93	1.02	3.77	1.16	3.86	0.91
Availability of software	4.64	0.72	4.66	0.65	4.58	0.84
Manufacturer's reputation	4.36	0.88	4.22	0.97	4.19	0.94
Availability of service	4.31	0.95	4.61	0.75	3.82	1.31
Quality of technical support	4.02	1.04	4.47	0.78	3.50	1.29
Product reliability	4.49	0.80	4.60	0.72	4.40	0.87
Price	4.20	0.85	4.23	0.84	4.27	0.87
Warranty	3.73	1.09	4.18	0.94	3.10	1.38
Average	**3.72**	**1.03**	**3.92**	**0.98**	**3.45**	**1.06**

compatibility with other computers, and price. The areas of greatest disagreement were local area networking and telecommunications capability. Disagreement was also high for portability, size, and graphics.

In judging future criteria, the largest increases in importance were for local area networking, quality of technical support, warranty, and keyboard functions, with portability, ease of operation, telecommunications capability, and availability of service close behind. This outcome seems to reflect the emerging technology and, at the same time, pragmatic concern with keeping systems operational. Availability of software still had the highest rating.

As events have developed, the judgments regarding future criteria were rather accurate. Networking and connectivity are dominant concerns at the larger institutions and are increasing in importance everywhere. The move is to campuswide connectivity, with all computer resources integrated and access available to all students, faculty, and administrators (Bruder and Hertzberg 1988; Janus 1987; Mason 1987; Ohler 1987). The goal is to support the entire organization with available access across families of computers and distributed resources and to do so in a way that is invisible to the user (Harvey 1988).

The availability of software continues to be a major concern. Early in 1986, EDUCOM undertook its Software Initiative to stimulate the development and distribution of software in higher education and to allow software to emerge "as a full complement to reading, lectures, and discussion." The announcement of the project early in 1986 stated, "The market for software is immature, balkanized by machine incompatibility and beset by logistical problems" (EDUCOM 1986).

Use of Microcomputers

Institutionwide use by students

Chief decision makers were asked whether students were required to use microcomputers in their institutions. Ninety percent responded that certain courses required the use of microcomputers. When separated by type of institution, the figures were 90 percent for public four-year colleges, 80 percent for private four-year colleges, and 100 percent for two-year colleges. The respondents were then asked how students actually used microcomputers (whether or not such use was required). Results are shown in table 8.

Overall, the greatest uses were reported for word processing, working with math and statistical problems, business education applications, and programming, and the lowest use was for research. Substantial differences existed among institutional types on several items, however. Two-year colleges reported the greatest use in all categories except research (where little emphasis is traditionally placed). Among four-year colleges, use was substantially greater in private institutions for word processing and math and statistical problems and substantially greater in public institutions for research and programming.

The EDUCOM Software Initiative concluded in a May 1987

TABLE 8

STUDENTS' USE OF MICROCOMPUTERS REPORTED BY CHIEF DECISION MAKERS

	Public 4-Year *N=30*	Private 4-Year *N=30*	2-Year *N=30*	Total *N=90*
Word processing	70.0%	80.0%	93.3%	81.1%
Math and statistical problems	63.3	83.3	96.7	81.1
Business education applications	76.7	76.7	90.0	81.1
Record keeping	33.3	33.3	56.7	41.1
Research	53.3	26.7	16.7	32.2
Programming	76.7	66.7	96.7	80.0
Other computer science use	36.7	33.3	40.0	37.8

report that microcomputers had to that time been used widely for word processing and spreadsheets but predicted greater use of instructional software in a variety of fields (*Electronic Learning* 1987). More recent reports note increasing use in such fields as art, history, medical education, and French history (MacKenzie 1988; Pollack 1987).

Institutional requirements for students to purchase microcomputers have been discussed in the literature; 98 percent of the institutions participating in the study indicated that they did not require such purchases and did not expect to do so in the future. As of 1987, this trend had slowed and, other than the three service academies, no colleges or universities had joined the 14 that then required students to buy computers (Turner 1987). The trend appears to be rather for campus units, such as bookstores, to make equipment available at a deep discount to students who want it (Kass 1988; Kass and Kinley 1988).

Personal use by faculty and staff
Study participants were asked about their personal use of microcomputers, and 453 (63 percent of the total group) reported that they used them in their work at their institutions. The greatest use by far was for word processing (85 percent). A far-distant second was research (38.6 percent), followed closely by keeping students' records (36.9 percent), math and statistics (36

percent), and classroom instructional support (35.5 percent). Fewer than one-fourth of respondents used them for anything other than word processing.

Thirty-two percent reported that they owned their own microcomputers, and over half of the respondents (52 percent) not currently using microcomputers in their work indicated that they expected to begin using them for word processing in the next two to three years. Other applications likely in the future included records management (37.2 percent), classroom instructional support (35.8 percent), business applications (33.4 percent), students' laboratory use (32.1 percent), math and statistics (29.9 percent), and faculty research (25.8 percent).

Use by schools and departments
Table 9 shows type of use by schools and departments, with results categorized by type of institution. Use was greatest in public four-year institutions and least in private four-year institutions. Public four-year schools reported greater use of microcomputers for research; two-year schools reported greater use for instruction. All used them substantially for administration.

TABLE 9

TYPE OF USE IN SCHOOLS AND DEPARTMENTS BY TYPE OF INSTITUTION

	Public 4-Year *N=240*	Private 4-Year *N=240*	2-Year *N=240*	Average *N=720*
Research only	1.7%	0.8%	0.4%	1.0%
Instruction only	3.3	7.5	11.7	7.5
Administration only	11.3	10.0	8.8	10.0
Research and instruction	5.8	2.5	0.4	2.9
Research and administration	6.3	2.9	0.4	3.2
Instruction and administration	10.0	21.3	36.6	22.6
Research, instruction, and administration	48.3	29.2	20.4	32.6
Subtotal: Some type of use	86.7%	74.2%	78.7%	79.8%
Microcomputers not being used	12.9	22.9	19.6	18.5
Don't know or no answer	0.4	2.9	1.7	1.7
Total	100.0%	100.0%	100.0%	100.0%

Financial and Other Commitments

Institutionwide commitment

The 60 decision makers who indicated that their institution had a policy or plan for microcomputers were asked about the institution's total financial commitment for hardware, software, construction, and other costs. Answers are summarized by category in table 10.

The amount committed to an institutionwide microcomputer plan ranged from under $50,000 to over $2 million. About 65 percent had committed under $500,000; the median amount was approximately $200,000. Eight schools had committed over $1 million.

The 60 decision makers from institutions with a policy or plan were also asked about source of funding for their current program. Major sources, categorized by type of institution, are summarized in table 11. The funding patterns in table 11 are strikingly different. Public four-year schools got about half their funding from state allocations and almost half from general revenues. Private four-year schools relied very heavily on general revenues and also depended more heavily than the others on tuition. Two-year schools relied very heavily on state allocations. These patterns undoubtedly reflected general funding patterns in the different types of institutions.

Several other funding sources were reported, though they were quite few in number relative to those reported in table 11. Included in the additional sources were grants, gifts, donations from vendors, capital funds, Title III funds, bond issues, and even, in one case, a lottery.

TABLE 10

TOTAL FINANCIAL COMMITMENT AMONG INSTITUTIONS WITH PLAN

(N=60)

Cost	Percent
$50,000 and under	11.7%
$50,001 to $100,000	18.4
$100,001 to $200,000	20.0
$200,001 to $500,000	15.0
$500,001 to $1,000,000	8.3
$1,000,001 to $2,000,000	10.0
Over $2,000,000	3.3
Don't know or no answer	13.3
Total	**100.0%**

TABLE 11

MAJOR SOURCES OF FUNDING OF MICROCOMPUTER PLANS

	Public 4-Year N=25	Private 4-Year N=21	2-Year N=14	Total N=60
General revenue	44.0%	66.7%	28.6%	48.3%
Student-fees	24.0	4.7	0.0	11.7
State allocation	52.8	0.0	100.0	45.0
Tuition	12.0	28.6	21.4	20.0

Respondents from schools with plans indicated that the average cost of the microcomputer systems in use was under $3,000. Forty-four percent stated that the student paid less than 10 percent of the total cost of the computer. About two-thirds of the institutions paid the total cost themselves.

The respondents felt that their future sources would remain very similar to current sources. They expressed concern about increasing costs as plans expand and large purchases are made. Many institutions will be unable to meet all of the costs associated with students' use of microcomputers—an especially difficult problem for private institutions, which rely so heavily on nontax revenues and tuition. A trend is growing for schools to charge a fee for students' use of computer labs (Shalvoy and Dersipilski 1987).

Commitments in schools and departments

In the assessment of the commitment to microcomputers in schools and departments, administrators and faculty members were asked when they expected a decision to purchase additional microcomputers, whether funds were already approved for purchasing, and if so how much was allocated.

About 54 percent of the respondents expected their organizational unit to purchase additional microcomputers within the next year, and another 27 percent expected additional purchases at some later time. Results were similar across institutional types. The data suggest that private four-year colleges will not purchase their machines as soon as the others. Overall, the results leave no doubt of a broad realization of the need for more microcomputers and a strong commitment to increase the number of microcomputers used in schools and departments.

Administrators and faculty members were then asked whether, to the best of their knowledge, funds for purchasing additional microcomputers were already allocated in their schools or departments. Slightly more than one-third reported the funds already allocated, and another 18 percent either did not know or did not answer the question. Fewer than 50 percent said that funds were not yet allocated. Tax-supported schools were somewhat more likely to have funds currently allocated. Of the 247 respondents who stated that their schools or departments had funds allocated, only 51 were able to indicate how much had been allocated.

The evidence is clear that institutions, schools, and departments are strongly committed to greater use of microcomputers. Tax-supported schools are ahead in current use and in funds allocated for future purchase, but all types of institutions clearly intend to broaden their use of microcomputers for instruction, for administrative activities, and for personal tasks of faculty and staff.

Summary and Conclusions

This section reported findings of an April 1986 survey in five major areas: existence of a policy or plan, policy makers and decision makers, criteria for selection, use of microcomputers, and commitments:

- *Existence of a policy or plan*. Overall, the results suggest an emerging area that has developed faster than expected and with which existing planning mechanisms have consequently been unable to cope.
- *Decision makers*. The committee structure is the dominant means of selecting hardware and software, whether decisions are institutionwide or for individual schools or departments.
- *Criteria for selection*. Availability of software, the operating system, compatibility with other machines, product reliability, price, ease of operation, and the manufacturer's reputation were most important in past decisions. Criteria expected to be more important in the future included local area networking and telecommunications capability.
- *Uses of microcomputers*. Word processing, solving math and statistics problems, business education, computer science, and administrative use were cited.
- *Financial and other commitments to microcomputers*. Financial commitments to purchase microcomputers aver-

> aged about $200,000. More than 80 percent of administrators and faculty indicated that their units would purchase additional microcomputers in the near future, though fewer than half said that funds for the purchase had already been allocated.

The most forceful, influential development has been the growth of the idea of campuswide integrated networking as a goal and of the concept of total connectivity of information resources. In fact, 1988 has been called the "year of the local area network" in higher education (McCarthy 1988). Two or three years ago, few people could even imagine the scope of this change, and the ultimate extent of its impact is still seeping into the consciousness of many responsible persons.

The survey results suggest that use of microcomputers has developed rather haphazardly, that events occurred faster than planning processes were structured to handle. The lack of adequate planning in the past and of a coherent concept of how microcomputers should in the future be phased in and used in higher education is clear. The increasing momentum of the information revolution means that better planning is not just desirable—it is essential.

PLANNING PROCESSES

Many processes are used in planning for microcomputers in higher education. Most institutions develop their own plans to meet special needs and missions. These formal and informal processes are based on their particular experiences or adopted from one or more of the commonly recognized planning processes in the field. This section, presents (with examples) several processes identified from field observations and the literature (see, e.g., Meredith, Cope, and Lenning 1987; Meredith, Lenning, and Cope 1988; Morrison 1987; and Norris and Poulton 1987).

Six processes provide a broad framework for categorizing institutional efforts to plan for microcomputers: (1) "muddling through," (2) the reactive process, (3) long-range planning, (4) environmental scanning, (5) strategic planning, and (6) tactical planning. These processes can work in conjunction with one another in an institution at any one time.

Institutions that wait, hoping to stay ahead of obsolescence, cannot win, as most equipment is obsolete when it is delivered or will be within a few months.

Muddling Through

Some institutions have a very difficult time responding to the continuing changes in technology, and the response is almost always influenced by limited resources and lack of knowledge of how to proceed. Another even more important factor is the institution's mission and purpose. Its context and direction are changed only with great difficulty. Why is this change so difficult?

Colleges and universities are by nature internally diversified, with power and decision making spread throughout the disciplines. The larger the institution and broader its disciplinary offerings, the more it is true. The decision-making process has traditionally been carried out by committees. Institutional history and direction, faculty interests and power, and long-range goals and objectives influence the process. Unfortunately, much of the decision making has not envisioned the future more than for a short time, so most plans are not implemented completely as initially projected.

This difficulty is an important factor in institutions' planning for technology, as they are prone to follow current directions with marginal adjustments. A process that describes such a scenario is "muddling through" (Lindblom 1959), which proposes the abandonment of long-range planning and long-range solutions and proposes in their place making small marginal changes, noting the impact of the changes, and adjusting decisions and direction as the institutional environment changes.

One example of this process is an institution's deciding to establish and noting the impact of establishing a local area network for its computer science department and sciences before establishing them for other disciplines. In this setting, the institution's overall purpose a d course are not changed. The advantage of this action is that the institution has the opportunity to evaluate the impact of a marginal decision affecting a small segment of the disciplines. Resources are more effectively allocated with a decrease in the probability of error as decisions are made for the entire institution.

If the commitment to a course of technology has already been made in an institution and no major changes occur in that technology, muddling through may work. Advances in computer technology have been rapid and pervasive, however; and the impact has been important in causing institutions to consider entirely new missions. In this instance, muddling through is not necessarily the most effective planning response.

Another associated problem in the field has to do with commitment to equipment. Once equipment is purchased, it becomes part of a long-range commitment. It must remain in use until it justifies the cost of its investment. In this case, muddling through may be a reasonable response from an inst ation. Perhaps the biggest problem with this process is that it does not allow institutions to make radical decisions to meet the changing conditions of society.

The Reactive Process

Technology moves so fast that even the most advanced institutions find themselves reacting to its impact at one time or another. A more noticeable reaction in this field is institutions waiting until they are certain their decisions about the technology have been tried and tested successfully before implementing them themselves. As such, institutions find themselves in a position of reacting. In one sense, reactive planning—the process of acting on a problem once the nature and conditions it produces become evident and clear enough to respond—is rather common in institutions as they attempt to deal with modern technology. The process generally does not wait until all conditions are studied and understood.

Technology has and will continue to produce its significant share of reactive planning. One example of the role of reactive planning in the field is with manufacturers of microcomputer equipment, who seem to be either leaders or followers. The leaders take enormous risks based on marketing studies that may lead them to hardware designs that will have little impact—or capture a significant share of the market. This case could occur when manufacturers set standards for hardware and software as in the case of IBM with the OS/2 operating system and PS/2 line of microcomputers. The followers, on the other hand, wait until new equipment is on the market. These vendors try to duplicate or improve their competitive products and often do so at less cost. This scenario has a dramatic impact on the higher education market. Institutions that buy early can generally get a considerable price break from manufacturers as an incentive, but they also stand the chance of buying equipment that may not have been thoroughly evaluated to meet their special needs and requirements. Institutions that wait for the "best" equipment and prices to come on the market, however, may not be able to stay abreast of the changing needs of the field or compete for students.

An example of solving a planning problem reactively is a liberal arts institution's discovery that a competitor has attracted a considerable number of its students through the establishment of a campuswide microcomputer system proclaimed to facilitate students' learning. Realizing the effect of the loss of students, the liberal arts college might react by establishing its own campuswide microcomputer program.

Institutions that wait, hoping to stay ahead of obsolescence, cannot win, as most equipment is obsolete when it is delivered or will be within a few months. Even special prototype equipment and software can hope to capture only a small window in a year or two. The key point to note in reactive planning is that institutions must react *correctly* to solve problems.

Traditional Long-range Planning

In the field of microcomputers, traditional long-range planning has characteristics found to limit institutional efforts to plan effectively for technology. This process assumes that the external environment, which includes the emerging needs and requirements of society for its work force, is stable. In turn, it emphasizes stability in planning, operating within an implementation period of five to ten years. One office or unit generally is responsible for developing a long-range plan for an institution because central control is necessary. One related assumption is that the process can be developed in the closed environment of an institution with an internal focus. The tradition and history of an institution, with their inherent stability, are very important factor and are taken carefully into consideration in implementing this type of planning. As such, institutional governance and budgets have considerable influence on the process. To get information to formulate budgets, quantitative data are required.

Long-range planning attempts to achieve an orderly blueprint in which planning decisions are carefully analyzed and deduced. The products of the planning are emphasized, generally at some specific and scheduled time. Efficiency is stressed as delays in carrying out the process can be costly. The point of reference for this planning is the current time, with future projections made from it. Ambiguity in understanding changes conditions and causes the process to stop, so every effort is made to avoid it. Tried and tested methods of solving problems are keys to the process. Efficiency rather than effectiveness is important, and institutional leaders with the greatest influence are the ones who shape the plan—which means of course that the weaknesses and strengths of the individuals are carried over to the plan.

A problem that could be encountered in this process, for example, is an institution deciding to purchase inexpensive computers in volume from a single manufacturer. The purchase is based on extensive research in microcomputers, and the full-scale implementation of the system is to be spread over five years in order to capture the payback on the investment. During the second year of the long-range plan's implementation, a major breakthrough in technology leaves the manufacturer's computer significantly behind in capability. The institution recognizes that the only way out is to scrap its current plan and equipment, but the enormous commitment of time and resources made by faculty and students means such a change in direction is not possible. Long-range planning by itself does not always provide the flexibility to change direction easily.

Unfortunately, the field of microcomputers exhibits no stability and comes with no real tradition. Microcomputers have been on the market only a few years, and campus systems have followed their availability. Technology is constantly in a state of flux and change. Some characteristics inherent in traditional long-range planning do not match well with the conditions of technology. Modifications through the infusion of other processes or adjunctive methods like environmental scanning must be used to bolster long-range planning to be effective in planning for technology—and specifically for microcomputers.

The key characteristics of traditional long-range planning are summarized in table 12.

Environmental Scanning

Perhaps nowhere else than in higher education does the external environment play such a critical role in institutional planning. Without a careful and deliberate assessment of technology, neither colleges nor their departments can respond to students' needs and the societal requirements that create them. The external environment must therefore be carefully and continually

TABLE 12

CHARACTERISTICS OF LONG-RANGE PLANNING

1. Emphasis on stability
2. Tradition oriented
3. Budgets and structure of governance heavily influence results
4. Emphasis on concrete and objective data
5. Blueprint for future decisions
6. Deductive and analytical
7. Product oriented
8. Focus on extrapolation
9. Oriented toward future decisions, looking from where we are now
10. Reactive
11. Inaction when ambiguity exists
12. Internal focus
13. Opportunistic orientation
14. A reliance on the tried and tested
15. Lock-step process
16. Univariate
17. The most persuasive persons set direction
18. Institutional strengths and weaknesses are the primary determiners
19. Emphasis on facts and the quantitative
20. Emphasis on doing the right things
21. Orientation toward efficiency
22. Science
23. Plan
24. Planning office carries out decisions
25. Closed and internal focus

Source: Meredith, Cope, and Lenning 1987.

evaluated. Realization is growing of the significance of environmental scanning in planning for technology in higher education. This process was developed by corporations to enhance the collection and analysis of information from outside. Environmental scanning designed to facilitate long-range planning essential to succeed in business and industry allows input into the long-range planning cycles, correcting them to modify an organization's direction to improve productivity.

The process has four stages (Morrison, Renfro, and Boucher 1984). The first requires scanning the external environment for emerging trends and issues that threaten or provide organizational opportunities. The next stage evaluates and ranks each trend and issue as to its likelihood of emerging and the nature and degree of its impact on the organization. The third stage, forecasting, develops an understanding of the likely future for the most important trends and issues. The fourth stage monitors the trends and issues for their continued relevance and evaluates the accuracy of earlier forecasts.

The process is relevant to colleges and universities planning for the conditions imposed by technology. It makes visible information from society that can strategically affect planning for the development of microcomputers. It greatly enhances and structures information from society—specifically, from all the external environments from technology that influence the development of microcomputers (Morrison 1987). The process has as its objectives being able to (1) detect scientific, technical, and economic factors that can affect organizations; (2) uncover and define potential threats, opportunities, and/or major changes implied by the factors; (3) promote and focus future plans; and (4) alert institutions to trends that are converging, diverging, speeding up, or interacting (Coates 1985). These objectives are critical to the needs of the field of microcomputers.

Long-range planning for microcomputers is not an effective process because of the constant changes in technology. Strategic planning allows corrections in the system, but few institutions have seriously considered the adjunctive process of environmental scanning to enhance future projections as a formalized, integrated element of their planning. With the incentive to meet the critical needs of technology, environmental scanning may find its place as one of the most important processes of augmentation in planning for microcomputers.

Strategic Planning
During recent field visits, some of the larger multipurpose institutions indicated that strategic planning is the major process used in orchestrating their management of technology—which may or may not be the case as some confusion exists about understanding what strategic planning is. What institutions may have meant is that they are using several important strategies they have combined and linked to constitute their effective planning process. Institutions may also have meant they are making strategic decisions regarding planning. The following criteria can help institutions determine whether they are addressing strategic issues or making strategic decisions. The issues or decisions (1) define the institution's relationship to its environment; (2) generally assume that the entire institution is the unit for analysis; (3) depend on information (input) from many functional areas of the institution; and (4) provide direction for and constraints on administrative and operational activities throughout the institution (Shirley 1983).

Strategic planning has some very specific parameters that are becoming increasingly important for institutions attempting to plan for technology. Part of the confusion in whether institutions are using strategic or another type of planning lies in previous understandings of strategic planning (Meredith, Cope, and Lenning 1987). Past definitions have been too broad and all-encompassing and many types of planning would have fit previous definitions. A current definition of this important process provides a more focused framework for determining whether or not an institution is using strategic planning:

> *Strategic planning, a relatively new management tool, is not simply an aggregation of budgets or a collection of management techniques to address all the issues facing an institution. Strategic planning is an open systems approach to steering an enterprise over time through uncertain environmental waters. It is a proactive problem-solving behavior directed externally at conditions in the environment. It is a means to find a favorable comparative position in an industry where there is continual competition for resources. The primary purpose is to link the institution's future to anticipated changes in the environment in such a way that the depletion of resources (money, personnel, students, goodwill. . .) is slower than the acquisition of new resources* (Cope 1986).

When institutions differentiate strategic from long-range planning, a number of distinctions emerge that are critical to planning for microcomputers.

Strategic planning is dynamic and responsive to the changing environment. It has a distinctive mission. It operates most effectively with single or few planning objectives and purposes, making it an important tool for issues related to technology and specifically to the microcomputer. Results are open to change through the influence of new conditions and circumstances. "Strategic planning is the activity through which one confronts the major strategic decisions facing the organization" (Norris and Poulton 1987, p. 6). Consensus among planners is a dominant characteristic of the process. Results are not locked into a blueprint. A vision of the future guides current decision making. The process is viewed as important to the entire institution and monitored by institutional planning groups and administrators. Planning is proactive, not reactive. Institutional environment and context are the primary determiners of the plan. Emphasis is on doing the right things. This emphasis should then be concerned with hiring effective, rather than simply efficient, people. Planning committees and staff should be those who are determined to foster, support, and implement the planned strategies. Decisions are not locked in place; rather, they flow in a stream as conditions and needs arise and as the conditions and vision of the future changes.

In this process, the institution is open to the external environment—the technology and society in this case. Considerable institutionwide confidence exists in the decisions that are made, as they reflect the context of the institution as a whole. This process really becomes effective when linked to the other (operational) planning efforts in an institution. Even when ambiguity is present, the process allows entrepreneurial and action-oriented input because of the enhanced confidence in the planning decisions.

Strategic planning is very well fitted to the conditions and circumstances affecting microcomputers in institutions of higher education. The development of the technology is dynamic and constantly changing. Increasingly sophisticated and faster computers are characteristic of the emerging field. Expert systems and software for artificial intelligence are in use in the industrial sector and are important structures for instruction and administration.

In the computer field, carefully sculptured institutional mission and purpose are critical in addressing societal requirements for students. Institutions develop and revise their missions, addressing issues like computer access for students and faculty and campuswide connectivity and integration of computer services. Business and industrial alliances keep institutions knowledgeable of technological developments. Missions include a vision of the future formulated through understanding of the technology, projected needs of society, and requirements of the labor force. Institutional planning for microcomputers depends on understanding technology. For this reason, an institution must be consistently focused on the external environment, ready to react to challenges on irregular time frames.

An institution must therefore analyze opportunities, anticipating the sudden and not so sudden changes in the external environment to be open and ready to modify expected results while concentrating on doing the right things. The constant interaction of key groups in the planning, with their suggestions of new and improved strategies, can result in a synergistic effect for planning efforts as well as help gain consensus on important institutional issues and directions. The characteristics of strategic planning are summarized in table 13.

Tactical Planning

Tactical planning is an important part of the continuous effort with institutions facing the changing dynamics of the computer field. This method of planning occurs within the scope of institutional activities. It is short range in nature (one to three years duration) and aimed at the specific components of planning. The process is aimed at producing useful and usable results from planning activities, quickly and efficiently. It is concerned with the most efficient allocation and manipulation of resources and programs to achieve planning objectives. It has an important utility in the microcomputer field, where tactics of efficiency are critically needed to coordinate administrative, research, and instructional procedures or to carry out such things as new curriculum designs that require careful internal decisions.

An example of such planning is an institution's purchase of new equipment in July for a campuswide computer network, required to be fully operational for all students and faculty by September. The administration realizes that only the cooperation and coordination of all the disciplines and staff can facilitate this goal. At a meeting with all the interested groups, each

TABLE 13

CHARACTERISTICS OF STRATEGIC PLANNING

1. Dynamic and change oriented
2. Mission oriented
3. Open and participative in terms of influence on results
4. Emphasis on subjective and intuitive data
5. Vision of the future to guide decision making today
6. Inductive and integrative
7. Process oriented
8. Anticipative, trying to anticipate sudden and not so sudden changes
9. Current decision oriented, looking from the future
10. Proactive
11. Entrepreneurial and action-oriented, even when ambiguity exists
12. External focus
13. Opportunity analysis
14. Emphasis on innovation and creativity
15. Continuous and ongoing
16. Synergistic
17. Consensus oriented in determining direction
18. Institutional environment and context are primary determiners
19. Emphasis on opinions and the qualitative
20. Emphasis on doing things right
21. Effectiveness oriented
22. Art
23. Stream of decisions
24. Institutionwide development
25. Open and external focus

Source: Meredith, Cope, and Lenning 1987.

one indicates what it can do to facilitate the process. Central staff coordinate planning components with the advice of the planning committee and sequentially schedule them with the dates and times needed to meet the deadline. One of the most effective tactics in institutional planning is to win support for the planning process from the faculty, administrators, boards of trustees, and students.

Summary

Colleges and universities are searching for planning processes that effectively address the problems and prospects created by advancing technology. Strategic planning, when including envi ronmental scanning, provides a comprehensive approach for institutions managing technology, but it must be linked to the other operational planning activities in an institution for it to be truly effective.

One study of whether strategic planning made a difference after a period of several years of implementation determined that schools using that process reported greater satisfaction, believed they were getting better results, and determined that they were actually achieving increasing funding (Meredith, Lenning, and Cope 1988).

None of these processes alone can describe the type of planning used in any one institution. One reason is that most institutions use many types of planning at the same time. Higher education institutions are distinctive, and that distinctiveness requires a customized approach in which strategic planning is linked to the institutions' regular planning. As such, fitting institutions into any one process is difficult, if not impossible. The processes described in this section provide important structures by which institutions can view their own mix of planning for microcomputers as a basis for improvement.

EXAMPLES OF INSTITUTIONAL PLANNING

The previous section presented widely recognized planning processes used in higher education as a basis for examining institutional planning; it determined that colleges develop their own combinations of planning processes and strategies to manage technology. This section describes eight selected institutions that encouraged planning from all levels inside and outside their campuses to ensure maximum participation to foster and evaluate decisions about technology The institutions spent considerable time and resources to determine their strengths and weaknesses before planning for technology. While considerable operational planning occurred on the campuses, it was not pervasive throughout the institutions. A planning atmosphere was created in which key representatives from all disciplines and the administrative staff were included in the planning process.

The eight colleges and universities were selected because they provide examples of strategies that can serve as models for other institutions, are recognized nationally as leaders for their exemplary planning and implementation in the computer field, and represent different segments of higher education in terms of mission, environment, and size.

Each illustration provides a statement indicating the context in which the planning has taken place and a summary of key planning efforts tied to characteristics of strategic planning. The end of the section contains an analysis of planning strategies common to the institutions compared to the characteristics of strategic planning outlined in the previous section.

The descriptions were prepared through an examination of planning documents and field visits to the colleges. The case studies have been revised several times, based on the institutions' changing plans. Two of the original institutions withdrew from the group because they no longer follow their original planning, thus making the illustrations inaccurate. The institutions themselves reviewed the descriptions presented here.

Brown seeks to make state-of-the-art technical solutions as available, usable, and relevant to those in the humanities as it has been to those in traditionally more technical areas.

Brown University

Over the past decade, Brown University has been heavily involved with the integration of information technology in its instructional and research missions. Brown, which has the dual missions of being a highly regarded liberal arts college and a research university, has been a special player in the growth of distributed computing on campus. Unlike many of the early leaders in this effort, which were largely technical institutions, Brown has emphasized the use of technology within the context of liberal arts, rather than focusing on the technology itself. Brown seeks to make state-of-the-art technical solutions as available, usable, and relevant to those in the humanities as it has been to those in traditionally more technical areas. The focus of the university's overall computing strategy has been to provide easy-to-use access to information, thus enabling the faculty, students, and staff at Brown to employ information technology to the degree that it facilitates their own scholarly goals.

Planning for campus computing is an ongoing process that involves many segments of the university community. The central computing organization, Computing and Information Services (CIS), oversees all academic, administrative, and data networking responsibilities for the campus. This group creates a rolling three-year computing plan every year. It also initially defines a set of specific annual objectives crossing all areas that the faculty Committee on Academic Computing (CAC) reviews. The Administrative Committee on Computing (ADCC) oversees administrative planning; an all-campus budgetary committee requests changes in the budget. CIS is responsible for operating a capital budget for computing expenditures related to capital acquisitions, and any variations of the amount within that budget must be approved through normal procedures. "Guiding Principles for Computing at Brown" has been adopted as the underlying premise from which all other policies and programs should stem.

The essence of Brown's computing strategy is to ensure faculty members' access to a variety of information services through the all-campus network. All faculty have access to their own workstation if they desire one, and CIS supports clusters, classrooms, and laboratories that house over 550 public workstations. No requirement or recommendation exists that students purchase their own computers, but nearly half actually do purchase a microcomputer. Using a combination of centralized and decentralized support structures, CIS provides consulting services 19 hours a day, free repair of machines owned by the institution, and a myriad of other services for users.

Much of the current planning at Brown involves the development of the network and accompanying services that would be available over the network. The Brown Internet consists of the combined interconnected departmental local area networks that serve the departments along with the backbone and the machines (gateways) that connect the departmental networks to the backbone. The Internet is operated over the campus broadband cable network called BRUNET and a BaseBand Ethernet. BRUNET was initially installed in 1981 and has grown to the point where it now connects 120 campus buildings and over 40 residence halls and supplies a variety of services to the campus. In addition to data transport services, it supplies channels for environmental monitoring and control of campus buildings and for security monitoring stations, and it provides video channels for satellite receiving stations and student-operated video productions. Plans are presently under way to augment the system with fiber optics for trunks and direct access into buildings needing extremely high transmission speeds.

Key planning strategies at Brown were to:

- Place the school in a position of national prominence;
- Ensure long-term committment of institutional resources;
- Strengthen the school's acknowledged mission through advanced technology;
- Implement institutionwide administration and control.

Clarkson University

Institutions concentrating on the sciences have had an advantage in their planning for microcomputer technology, although not all of them have done as well as Clarkson University. In preparing to coordinate its technology, the university appointed a dean for educational computing, who coordinates all campus computing, trains faculty, distributes and maintains microcomputers, and develops microcomputer software. The planning was directed through an initial study that determined institutional needs of faculty and students. Based on the study, faculty and administrators developed specifications for institutionwide computing. A single manufacturer was selected for the univers[illegible] to achieve economies of scale and to facilitate coordination among schools and with the college's mainframe. The engineering school was initially selected to coordinate the introduction of microcomputers into the curriculum, and an external advisory committee was set up to review progress and provide advice on future plans.

One innovation in Clarkson's planning was to use a prestigious lead school within the institution to initiate implementation of its plan. Administrators believed that an incentive to integrate microcomputers into the curriculum would probably work best; they therefore gave faculty members who promised to use one in their courses and to inform colleagues of their uses and results through informal reports their own microcomputers. Many of the faculty of all schools willingly introduced microcomputers into their courses with little or no urging. A key point is the initial use of one of the elements of long-range planning that turned into a component of strategic planning—using the most persuasive group to establish a precedent for using microcomputers. Faculty concensus became the key motivator for integrating microcomputers into the curriculum and campuswide use.

Key planning strategies at Clarkson were to:

- Require all students to own computers and to receive national recognition for the effort;
- Appoint an administrator for campuswide computing;
- Select a single vendor to take advantage of economies of scale;
- Establish the effort through a lead school that had the power and respect needed to implement the program;
- Concentrate the effort on the sciences, one of the university's recognized strengths.

Drew University

Considerable debate has been waged over the value of selecting a single manufacturer's microcomputer system for an entire campus. With the need for technology for an integrated campuswide microcomputing system—a direction many schools are taking—is it possible for an institution to go with one vendor for long? On one hand, such a move favors easy installation and use and cost savings from volume purchases. For a small institution, the factors are very important. On the other hand, no one manufacturer can continue to provide microcomputers that keep up with the latest technology. Initially, Drew decided to use the product of one manufacturer but with the idea that most of the microcomputers would operate as stand-alone systems. Today, every one of the institution's faculty, students, and staff can be integrated into its total campus environment with both voice and data. Several corporations are part of Drew's long-range plan and are essential to making it work. Drew's efforts have changed somewhat since its initiation into the microcomputer field in 1983. Its strategies for implementing its plan for microcomputers provide an understanding of how a small liberal arts college creatively addressed its vision of the future to provide campuswide computing services.

Drew University is nationally recognized as a highly competitive liberal arts institution with an enrollment of approximately 1,500 full-time undergraduate and 600 graduate students. In fall 1983, Drew took its first steps toward the integration of information technology into its liberal arts curriculum by giving every student and faculty member a personal computer, creating a new training and implementation plan for · e of computers, establishing a software library and user support structure, and upgrading the computer center to handle the new demands of its plan. In its beginning, Drew's plan included the concept of total use for all students, the use of a single vendor to facilitate servicing, training, and maintenance, low cost and common use of the same software for word processing and utilities, and the idea that students would use the computers independen. ,. The plan, conceived in 1983, has been fully implemented with a one-to-one ratio of personal computers to individuals. Drew now has an operational training and implementation plan, a software library with some 900 programs, and a modem computer center directed at its initiative.

A consensus-oriented administrative structure was designed to allow all campus users tc be involved in major decisions like the selection of vendors for hardware and software. The same structure allowed the operation and implementation of planning to be carried out by the small, dedicated staff of the computer center, greatly facilitating daily decisions and operations. As in many institutions involved in developing computer technology, a director of academic computing was appointed, reporting directly to a vice president for planning and communications. This vice president has the advantage of being able to orchestrate all planning for the university as well as planning for the computer system.

Because Drew is a small school not well known outside the liberal arts arena, vendors showed little interest in donating hardware and software. The company t. .t did initially provide hardware with continuing technical support was Epson America. An advantage for Drew was its ability to deal with a single vendor with which it had a volume purchasing agreement. Purchasing 500 or more units at the same time has allowed the university to get the systems at a low cost and to pass on the savings to students, who paid for the computers semester by semester through their tuition payments. Drew has now developed a special alliance/partnership with Bell Atlanticom, Digital Corporation, Intecom/Wang, and Octel to support its fully integrated voice-data communications network. Zenith provided the microcomputers.

Drew planned to be first in its implementation of total campus use of microcomputers and anticipated being recognized for this effort in the field and among a broader territory from which it traditionally has drawn its students. Drew's entrepreneurial objective of increasing enrollment through its initiative was achieved when, after its first year of implementation, applications rose about 40 percent. This level of applications has been maintained every year since Drew started its initiative, and the quality of entering students is at an all-time high, while enrollment has remained steady.

Drew's plan emphasizes integrating all operations within the university for the 2,000 terminals in dormitories, administration buildings, and department offices that will link the campus's 50 buildings. The system will feature full integration of voice and data with a terminal for every use.

Drew's comprehensive planning is based on three goals: (1) to improve the quality of education through course-related software; (2) to educate students to contribute to society; and (3) to redefine education as the thinking and problem-solving process closely bonded to human knowledge. All of Drew's planning has been based on linking these three goals, which provide the structure and direction for its planning for microcomputers.

Key planning strategies at Drew were to:

- Develop a policy for total use by all students, faculty, and staff;
- Develop a consensus-oriented administrative structure for all users to be involved in major decisions affecting planning, operations, and implementation;
- Appoint a central administrator to coordinate campuswide computing efforts;
- Plan to be first in implementing campuswide computing and through the resulting recognition attract more students;
- Develop a computer science initiative to support and enhance planning;
- Form an alliance with key corporations to assist in planning and implementing the total campus initiative;
- Develop a voice and data system that is a model for modern integrated telecommunications systems.

Drexel University

Drexel University saw from the onset of its planning that it would have to compete with other institutions in the use of microcomputer technology. As a university concentrating in the sciences, advanced computing was essential to its future, particularly because Drexel is a cooperative educational institution whose seniors spend a year and a half in industry on co-op assignments. Many different committees and groups were involved in planning for microcomputer technology—faculty, students, business affairs groups, facilities committees, the staff of the computer center, an instructional support group, a microcomputer users group, an equipment support group, a microcomputer program management team, and a selection committee. A central administrative office was established with an assistant vice president for computing and telecommunications. The aim of planning was to compete in science and technology, with the idea that Drexel would be a national leader in the field of microcomputers. One goal of the planning was to meet society's advanced requirements for computer support and sophisticated use within Drexel's special mission and competencies.

All students in every major were to learn to use a microcomputer as a tool for productivity. A common package of commercial software has helped the institution to accomplish this goal. Drexel also developed instructional software for virtually every major from which students can select needed software from a file server in the public cluster of microcomputers; over 1,400 files have been placed on that server by faculty alone. The campus has 13,000 microcomputers with the major emphasis in planning now on networking those machines for an easy exchange of software and ideas among faculty and students.

Drexel obtained a $2.8 million grant from the Pew Foundation to initiate the faculty's development effort. Buying from one manufacturer was planned to reduce costs for hardware and software. From the beginning, the faculty believed it would develop much of its own software and that it could be disseminated campuswide to students.

The plan at Drexel was designed to be synergistic from the beginning. Drexel had the correct ingredients to ensure maximum integration of all computer services. Its concentration in the sciences allowed it to more narrowly define its plan for computing. It was able to provide the same type of powerful computers at a low price that could be operated independently or networked to file servers, gateways, and mainframes, facilitating the use of the same operating systems and applications. A large number of highly trained faculty wrote their own software, which then became part of a pool of software available to students as part of a package. All efforts by faculty and students were effectively controlled from an administrative unit that oversaw the entire development plan for microcomputers. Also important was e central administration's commitment to go initially with a single manufacturer at a time marked by the emergence of many different, competing microcomputers. The result of t' planning was a highly integrated and managed computing environment tailored to the specific needs and requirements of Drexel's faculty and students.

Key planning strategies at Drexel were to:

- Attempt to become a national leader in using microcomputer technology with a concentration in the sciences;
- Involve users through committees to assist in planning systems;
- Direct planning toward competing in science and technology to establish Drexel's niche among institutions and to draw students from all over the United States;
- Use hardware from a single vendor and faculty-developed software available to all students and faculty;
- Centralize planning to achieve a highly integrated and managed computing environment;
- Have students own computers and use them in an integrated academic setting and on the job.

University of Iowa

Campuswide computing has the potential to reduce inequities among disciplines. Universal availability of computers and software from a central source allows all faculty and students access to computing services, in turn opening computing resources to disciplines that have not previously used computing services.

The University of Iowa's comprehensive plan for computing included the goal of coordinating computing services to ensure universal access and to reduce inequities among departments. In 1978, the director of academic computing began planning. In 1982, the university created an office of information technology to continue the planning and to implement the campuswide system for automation. During the planning, a number of issues emerged that directed the university's efforts—that information technology is essential to the future of students, faculty, and administrators; that the university must continuously support the development of technology; that its plan must allow for broad coordination and reduce inequities; and that the university's challenge is to provide for education, training, and awareness in the use and potential of information technology.

In the past few years, traditional long-range planning strategies at the university have changed, becoming modified to reflect strategic planning with a long-range perspective. The long-range viewpoint was essential to ensure consideration of the funds for equipment purchases and personnel committed over several years and to provide stability during the implementation of the computer program. The office of information technology's principal role was to concentrate on development and implementation of its strategic plan.

Most of the growth at the university was at the departmental level. One effective element in developing departmental computing has been the creation of a microcomputer support infrastructure through the academic computing center. Other elements effective in ensuring the implementation of its computer program have been comprehensive software and hardware support, training users, and volume discounts that have been effective inducements for standardization without rigidly enforced standards. These elements, coupled with the university's long-term planning strategy encouraging instructional computing partnerships between academic units and the computing center, have been a stimulus for departmental computing.

Key planning strategies at the University of Iowa were to:

- Coordinate computing services to ensure access and to reduce inequities among departments;
- Plan comprehensively for a total computing environment;
- Appoint a director of academic computing;
- Undertake a multiyear plan to ensure institutional stability of computing services;
- Develop a microcomputer support infrastructure;
- Develop a partnership between academic units and the computing center.

Lehigh University

A characteristic of strategic planning is to make current decisions based on a projection of future conditions and needs. Lehigh University attempted to analyze the needs of the emerging work force and the requirements of technology to plan for its total campus computer system, and it did so clearly within its institutional mission and scope. Lehigh's planning efforts in its response to technology demonstrated the capacity to envision correctly the future requirements of technology.

Lehigh University, though traditionally known for its engineering program, is also dedicated to fostering excellence in the arts and sciences, business and economics, and education. It has an enrollment of approximately 6,000 undergraduate and graduate students and is able to provide access to its computing facilities for all students through its campuswide networking system. Through the universitywide network, every student, faculty member, and administrator has access to a network server, mainframes, a library catalog, and external networks. All students have their own data lines and access to an electronic mail system in all residential housing units, and it is possible to contact any student directly through a network server's electronic mail subsystem. On campus, over 60 percent of all administrative correspondence is handled through electronic mail. Electronic billboards are available through the server for campus organizations, academic disciplines, and general public use. In addition to having access to public microcomputers and workstations, approximately 25 percent of the students own microcomputers that can be connected to the system through terminal access points in their residences. Software for the microcomputers is available online in the residences and at public sites.

The library's total catalog listing is continuously updated; it is available to anyone on campus through any terminal or computer connected to the network in residences, offices, laboratories, and public sites. Off-campus access is also available through a pool of modems. The library's online listing of 850,000 volumes includes standard referencing, location of materials, and current availability. University-held software is also part of the listing. Current plans include providing every resident on campus access to individually assigned television connections providing over 16 channels to support instruction.

Lehigh, a campus with many different minicomputers and mainframes, is currently committed to a single vendor for microcomputers. This commitment was made to facilitate acquisition of a large number of microcomputers and to simplify handling of technology that might have been difficult with a number of different, noncompatible vendors. Lehigh does not expect to remain committed to a single vendor over the long term, however. The emergence of new technology, particularly new architectures appearing in workstations and the IBM System 2, will necessitate considerin' numerous vendors.

From the very beginning of Lehigh's planning for distributed computing and communications services, its efforts were to place the university nationally in the forefront of the application of these technologies to its missions in research and education. The administrative structure for computing and communication, designed to facilitate implementation of its plans, consists of a single administrative office directed by the vice president for academic services. The director of libraries, assistant vice president for computing and communications services, and assistant vice president for facilities services all fall within this administrative group and are all responsible for operating and planning their respective organizations. Within the framework of Lehigh's long-range objectives, revisions to the plan are proposed yearly from the bottom up. Part of the university's current mission is a major emphasis on expanding the availability and quality of computer and communication services for all disciplines, in keeping with the university's multidiscipline orientation.

Most important in any institution are the level and intensity of the continuing commitment to planning.

Several planning strategies at Lehigh are important in facilitating the implementation of its planning for computers. A central administrator in charge of computing and communication has direct control over facilities. Because total campus networking is an essential element of the planning, the vice president for academic services is able to control implementation of the telecommunications system required for the campus network. Distributed computing and communication networking were designed to occur at the same time. The idea of institutionwide development with total access for all students, faculty, administrators, and staff to electronic network services, all campus computers, library data bases, and external computing and communication facilities was part of Lehigh's initial planning. The concept allows academic departments to have better control over classes through direct links with students.

Most important in any institution are the level and intensity of the continuing commitment to planning. The president and trustees at Lehigh have been committed to the long-range plan for computing and communications from the very beginning. Planning has attempted to achieve the consensus of all departments and administrators. As part of the continuing consensus

›n direction, faculty and administrators yearly update the long-term plan.

Key planning strateg' s at Lehigh were to:

- Develop a universitywide network link accessible by all disciplines to every student, faculty, and administrator;
- Move from a single vendor to several vendors as new technologies emerged to improve computing services;
- Consolidate and coordinate all computing services within a single administrative office and central administrator;
- Revise the long-term plan yearly based on changing conditions and emerging needs;
- Obtain a consensus in planning from faculty and administrators.

Princeton University

The central theme for planning for computing at Princeton University since the advent of its major thrust in 1983 has been that a great university requires great computing.* At that time, a report on proposed initiatives presented to the trustees of the university included the expansion of computing activities from the sciences to the humanities and social sciences. The report also supported expansion to more studer .. and faculty, from freshmen to research scientists, with a wider and more conveniently available range of computing tools, including access to more microcomputers and the central mainframe than had been available.

In 1984, Princeton obtained a $6 million multiyear grant from the IBM Corporation to assemble and refine an administrative and technical infrastructure. The grant provided a major impetus to accelerate the pace of acquiring a computing system. In 1985, a special faculty committee on computing recommended that a new senior administrative position, vice president for computing and information technology, be appointed to coordinate all university computing Shortly after the position was established, the vice president established five directorates (for information services, systems and technical support, administrative services, management information services, and advanced technology and applications) to coordinate all research, development, and operations.

*John Edwards 1987, personal communication.

In April 1986, the office of computing and information technology presented a five-year plan for enhancing computing at Princeton. The plan included steps to implement a campuswide, high-speed communications network, distribute workstations on campus, provide software to meet academic and administrative needs, maintain the total system, and increase the technical staff to support expansion of the system. Princeton's administrative structure for computing incorporated existing service organizations, including media services, printing services, alumni records, management information services, and the computing center. The staff has now risen to over 200, and it may rise even more as new needs and requirements become evident.

Princeton's concept of planning has excluded the commitment to any single vendor to keep abreast of the technology and provide the advantages of competition when negotiating with several vendors.

From the beginning of Princeton's effort, the committee structure including faculty, administrators, and trustees has been integral in making decisions for computing. The understanding and perspective to develop effective computing were available from the beginning, and the faculty committee on computing, begun in 1983, continues to meet monthly. Princeton was both entrepreneurial and action oriented in obtaining the IBM grant to carry out its planning. Princeton's mission was clearly a central theme in its planning, and consensus on the planning effort emerged from the faculty committee that recommended the planning and administrative structure for computing. A key element in Princeton's planning has been a comprehensive and centrally controlled institutional administrative structure that maintains and coordinates the entire campuswide effort.

Key planning strategies at Princeton were to:

- Concentrate significant resources over several years;
- Address the needs of all users in the plan;
- Appoint a central administrator with links to all research, development, and operations functions;
- Exclude a commitment to any one vendor to stay abreast of technology;
- Ensure a comprehensive, centrally controlled ad.. n strative structure;
- Ensure an exemplary, scholarly environment that provides all tools needed to enhance research for faculty.

Stevens Institute of Technology

Some institutions view a very careful and structured planning process as critical to their response to technology. From the very beginning of its planning, Stevens Institute of Technology has used strategic planning to ensure effective decisions and programs to prepare its students for high-tech futures. The institutional mission, its vision of the future, the external focus on emerging technology, its institutional context, and comprehensive faculty and administrative consensus had been critical elements in Stevens's planning process over the period since the initiation of its efforts to achieve an effective campuswide computing system. The time and resources to implement its plan have been extensive, but the results have been a nationally recognized computing system

Stevens Institute of Technology is a private technological university dedicated to the pursuit and dissemination of knowledge through broad-based programs in engineering, science, management, and computer science. Since 1978, the organizational structure for computing and information-related activities has evolved into an integrated system designed to serve teaching, research, and communications through computing. This evolution began with a grant from the National Science Foun dation intended to develop computer graphics that integrated simulation programming across curricula. This experience led to the faculty's organized effort to investigate the feasibility and implications of creating a comprehensive approach to computing in education that would enable undergraduates to become "computer fluent."

A wide variety of support mechanisms assist students as they work with computers at Stevens—assistants/consultants/tutors, workshops (during the summer before freshman year and throughout the academic year), and special documentation. The growth of a personal computer plan for students has been paralleled by the creation of a professional computer incentive plan (PCIP) for faculty. Approximately 00 of the 145 full-time members of the faculty have participated in the plan.

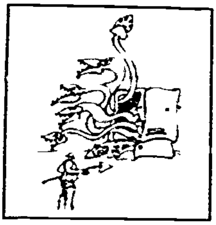
In 1985, Stevens defined a new strategic direction for computing by beginning the CREATE (Computing in Research and Education for an Advanced Technology Environment) project. Plans for the project were under development for three years before its formal announcement, with strong, unified efforts by faculty and computing staff. An objective of the project was to develop a multivendor, heterogeneous, network-based environment for communications that facilitated research, education, and administration. The initiative has been supported by a wide range of vendors, including Digital Equipment Corporation and AT&T. To facilitate project planning and the coordination of CREATE, the computing and information systems (C&IS) organization was formed, then headed by an associate provost. The computer center, management information systems, computer service center, and library are part of this organization. C&IS coordinates strategic planning, design, and support.

With the formation of C&IS (later changed to "information systems"), a 14-member committee on academic computing replaced the ad hoc faculty-administration committees All academic departments are represented on this committee, which meets monthly to consider strategic directions for CREATE and the personal computer program.

The computer center has grown from a traditional, central computing site to the computing and communications resources organization, responsible for major computing systems and distributed computing, including time-sharing, local area networking, and external communications. The staff fills traditional academic computing roles but is also fully involved in designing the network, evaluating hardware and software, supporting supercomputing, reviewing planned departmental communications and resources, developing documents planning system migration, and interacting with a variety of vendors.

A 1986 faculty survey of the use of computing revealed that computer assignments are widespread, involving a broad variety of computing activities (e.g., programming, simulation, computer-assisted instruction, and modeling). C&IS also provides support for faculty in the development of proposals for grants from industry and government. The Stevens software development support group was formed to provide centralized, coordinated expertise and materials to faculty planners to integrate computing in academics.

In 1986, the state of New Jersey awarded Stevens $3.4 million to develop its computer and communications center under CREATE. The development includes wiring the campus using fiber optics cable to link Ethernet networks, upgrading the central computing system !ding millions of dollars of hardware and software, and providing access to the network for students and faculty. During the same year, FIPSE (Fund for the Improvement of Post-Secondary Education) granted Stevens a three-year award to employ interprocess communication in a



networked environment to improve students' learning and to integrate thinking through simulation in chemical engineering, chemistry, and environmental engineering. This project will serve as a model for creating computer tools and sharing resources in computer-based teaching and research. Stevens also participates in a five-year, $1.6 million grant to support resources for access to the John von Neumann Supercomputing Center and NSFnet.

Key planning strategies at Stevens were to:

- Carry out a comprehensive investigation of external and internal forces that affect planning;
- Design an intensive computing environment to meet the institute's needs and objectives;
- Apply money from private, government, and state grants to facilitate planning and development;
- Consolidate all campus planning, design, and implementation under one central administrative office.

Conclusion

A number of similarities among the institutions presented in the case studies relate to the characteristics of strategic planning outlined in table 13 on page 54. The similarities are summarized in table 14.

TABLE 14

SIMILARITIES AMONG SAMPLE INSTITUTIONS

	References to Table 13
All sample institutions reported that the computing field is so dynamic and changing that a commitment to continuous planning is essential.	1. Dynamic and change oriented
All institutions indicated the need to strengthen their acknowledged institutional missions through the planning related to development of microcomputers.	2. Mission oriented 18. Institutional environment and context are primary determiners
Most of the institutions were creative in attempting to establish a niche for themselves in the field by first trying an innovative or exemplary idea that advanced the school and developments in the field.	14. Emphasis on innovation and creativity

Table 14 (Continued)

All institutions envisioned planning to lead eventually to campuswide computer networking to reach all students, faculty, and administrators.	24. Institutionwide development
Coordination, consolidation, management, and control of computing were essential parts of the planning of all institutions. Networking and connectivity emerged as significant issues in planning.	17. Consensus oriented in determining direction
Most institutions developed a planning process that included the integration of microcomputers within total campus computing.	6. Inductive and integrative
Most institutions anticipated and planned for such factors as changing technology and requirements of the work force while evaluating the impact of their own changing needs and requirements. Cooperative external relationships and alliances were developed and fostered between the institutions and manufacturers as an important element of planning.	8. Anticipative, trying to anticipate sudden and not so sudden changes
Every institution indicated that it had a vision of the future that served to structure and direct its planning. This vision was based on the expert observations of faculty, experts in the field, manufacturers, and planning research to guide the institutions' development. Subjective and intuitive data were considered along with objective data in planning.	5. Vision of the future to guide decision making today

Table 14 (Continued)

Institutions reported that planning for development of microcomputers involved advice from users and potential users represented on campus as an integral part of their development for microcomputers.	17. Consensus oriented in determining direction
Most institutions indicated that significant expansion of computer use would include those disciplines that have not previously used microcomputers, with the idea of effectively expanding the use of computers to all segments of the campus.	21. Effectiveness oriented
Most institutions projected future needs and work requirements of society as important components of their computing plans. The institutions did not wait for the computing field to emerge more clearly or to be able to project the precise future needs for their graduates.	10. Proactive
Decentralizing computer power and services has been made possible through microcomputers. All institutions projected decentralization of computing services as a key concept in their planning strategy to increase the widespread use of computing services while improving effectiveness and reducing costs.	21. Effectiveness oriented

Table 14 (Continued)

All institutions committed significant resources for planning and implementation development of microcomputers. Most institutions received grants and gifts from foundations, computer companies, public and private sources, and/or the government to assist them in planning.	21. Effectiveness oriented
All the institutions planned for a coordinated and centralized computing administration with a central administrator or manager, with consensus of the users a key element. The idea of computer partnerships emerged as an important concept in planning.	16. Synergistic 17. Consensus oriented in determining direction
The institutions viewed training as essential for all users, although methods of implementation varied widely.	22. Art
Most institutions indicated that they began their plans at least one year before any major implementation.	20. Emphasis on doing things right
Most institutions' plans ranged from one to five years. Revising the plans was viewed as a continuous process.	15. Continuous and ongoing
All institutions viewed their computing efforts to be important and innovative enough to gain recognition in the field, and all worked toward that end.	14. Emphasis on innovation and creativity

CONCLUSIONS AND RECOMMENDATIONS

A Clear Need

This monograph has analyzed the challenge posed by microcomputers in colleges and universities and assessed the current state of planning in response to that challenge. It now offers recommendations to help colleges and universities plan more effectively and prepare for the future.

While outstanding exceptions exist ng for the use of microcomputers in postsecondary education has not been very effective. Existing planning mechanisms have been overrun and have not coped well with the rapidly changing technology. Furthermore, while awareness of microcomputers is universal, the extent of its challenge appears not to be fully realized or understood at the highest levels in much of postsecondary education. One may thus conclude that a serious situation exists—that the need for improvement is real and, in fact, compelling.

The remainder of this section contains three parts: (1) a review of a set of operating assumptions that affect planning; (2) 10 recommendations for college and university officials to consider in planning for microcomputers; and (3) the authors' judgments about what might occur in the future and how present actions may affect society at that time. Given the possibilities now emerging, the challenge can indeed be classified as profound.

The recommendations should be viewed as guidelines rather than prescriptions. Each institution must implement them or not to suit its own situation.

Operating Assumptions

The following recommendations are based on a set of assumptions that the authors believe should be made explicit. In any logical system, the validity of conclusions drawn depends, among other things, on the validity of the initial assumptions. In considering the recommendations, the reader must be aware of the assumption and the extent to which he or she agrees with them. The overriding assumption of the whole monograph is, of course, that planning is desirable and requisite. Otherwise, four major assumptions underlie the recommendations that follow.

The computer is the most important invention of the 20th century and one of the central inventions in human history. The computer era started only about 40 years ago, and we stand at its infancy. Although its major influence will be felt in the 21st century, it has already had tremendous impact, providing a

The computer is the most important invention of the 20th century and one of the central inventions in human history.

glimpse of the power of information and of the workings of the information age. We cannot see very far into the future with much accuracy, but we have enough of a sense of it to know that the computer must be a key concern as we plan for the preparation of students and for the continuing viability of our institutions.

The move toward campuswide networking and connectivity will accelerate and shortly be considered the standard for all institutions. Connectivity has come on the scene so rapidly in higher education that it gives us pause in making projections for the future. Networking has been around for years, but the concept of integrating all resources of the institution through a network and making them easily accessible to faculty, staff, and students has only recently come into the general consciousness. Not all colleges and universities will be able to achieve it fully, of course, but all will see it as the ideal model toward which they strive.

The goal in building computer systems on campuses is universal use by all members of an institution's community(ies), including administrators, faculty, staff, and students. Microcomputers have the sociological effect of making computing easily available to everyone: Prepackaged applications programs have removed the need for esoteric programming, and connectivity places resources at everyone's fingertips. Front runners in the field have the stated aim of total use by all students, faculty, and staff on campus. Others are certain to fall in line.

Postsecondary education shares with the larger society the responsibility for bringing under control the power that knowledge provides to alter the environment. The day when a scholar or scientist could escape moral responsibility for his or ... work has passed, because possible consequences have become too grave, and the old saw that fundamental research has as its only purpose the production of new knowledge is invalid. The ultimate criterion of viability must be the capability to survive, and controlling the power provided by knowledge has become essential to survival (Beer 1972).

Recommendations

The following recommendations—for those who are aware of a need and who wish to improve—represent a set of actions that have been identified as helpful in responding to the challenge faced. Each institution must de ... implement them in the context of its own culture ... vironment.

Use strategic planning, with a ... onent of environmental scanning, as the most appropriate planning model for this situation. Most institutions seem to have been muddling through or merely reacting to technology, but a more proactive stance is probably more appropriate. Planning must be accepted as a continuous activity. Brown University, for example, decided where it wanted to be in the long run, realizing that this vision would change as conditions develop. Based on the long-range view, it develops detailed three-year plans and revises them at least once each year. It continually scans both the external and internal environments and is capable of revising its procedures as necessary.

Establish a central authority, at the level of vice president, to coordinate planning, computer use, and development of institutionwide networking and access. Each of the eight institutions described earlier found it necessary to set up a central authority; campuswide coordination is too complex to handle otherwise. Efficiently deploying scarce resources is always desirable but has often been missing in the piecemeal approaches of the past. More important, the move toward connectivity and campuswide networking demands that different components of the system be compatible and that the whole enterprise be approached systemically. The central authority must have responsibility for setting policy and direction in the development of an integrated information program. Princeton's central office, for example, has five directorates.

Establish clear responsibility in a single unit to maintain current information on all relevant aspects of computing and to inform decision makers about matters of concern. This is the use of knowledge turned in on itself. Connectivity in its broadest aspects can be conceived as an aid to use of knowledge. The integrated system connects knowledge to users, but usually in a passive way. The user must initiate the access; the approach taken must be more active. Major decision makers are often extremely busy and despite knowing better find themselves poorly informed in many situations. Because computing, communications, and networking require specialized knowledge, it is difficult for the generalist to know enough to make the best decisions. Ensuring an adequate level of information is a task the central authority must actively undertake.

Involve all faculty and staff in planning the institution's information system and build institutionwide support through a process of consensus. The recommendation for centralized authority seems on the surface to run counter to the traditions of collegiality and academic freedom in higher education. But what is involved is the authority to *coordinate*, not to coerce, and this distinction must be clear if one expects wide support for the enterprise. At the same time, many faculty have little contact with computers (except for word processing) and tend to be apprehensive of schemes for wider use. The need to build consensus among all faculty, if possible, is clear. Academe's traditional committee structure for decision making will work in computer-related decisions as well. The committee structure therefore seems the logical choice for building consensus. As all faculty and staff are to be involved in campuswide networks, a plan for using committees throughout the institution must be developed.

Develop an organizational infrastructure that supports the use of microcomputers throughout the institution and the broader use of networks and information sources. If something is to happen in an institution, it should be made so easy and so natural that anything else seems less desirable. Microcomputers will be more likely to be used if they are immediately available and properly maintained, and if they have user-friendly software. If they are remote and difficult, they are likely not to be used. Structural change is so traumatic that people often "pretend that they cannot see what their own eyes insistently report, rather than commit themselves to the reshaping [that] is necessary" (Beer 1972, p. 319). In addition to building consensus, and perhaps as an integral part of it, the institution must establish a supporting infrastructure, and it must be done deliberately. The University of Iowa, for example, created such an infrastructure through an academic computing center, partnerships between academic units and the computing center, comprehensive support for software and hardware, and training for users.

Integrate computing in all curricula, and locate or develop needed instructional software. A safe assumption is that the ready availability of suitable instructional software is necessary for faculty to use computers. And another safe assumption is that most faculty members will not secure this software on their own. Much educational software is on the market, so part of the problem may be finding it. In many cases, however, nothing suitable exists. In this instance, the institution must be prepared to develop it, individually or cooperatively wit! organizations like EDUCOM. Ensuring the availability of software must be part of the institution's planning.

Take active steps to secure a long-range financial commitment and adequate funding, including federal, state, and private sources in the strategy. Institutions must realize that any type of planning for technology requires a multiyear commitment of institutional resources and that comprehensive planning requires large investments of personnel, time, and money. Institutions with limited resources may find its implementation impossible. Thus, the gap between the haves and the have nots may widen. Perhaps the best advice is to know the ideal and then come as close to it as possible within available resources. This demanding planning program gives no excuse for surrender or apathy. Planners must vigorously seek resources and adjust plans regularly to fit current realities.

Train faculty and staff as a continuous, centralized function and support it with adequate funds. Training has emerged as one of the most important functions of campus computing, and it will continue as a requirement for the next few years. People must have the skills to do what they are asked. Training can be seen as a component of the supporting infrastructure, but training individuals to use computers is difficult because of rapid changes in the field and because of the variety of uses in a large postsecondary institution. Some institutions have established assistance in training through cooperative arrangements with local industries. The institution must be committed to significant training for all users—faculty, staff, and administrators.

Aim for synergy. Improving the use of knowledge should be included in the institution's plans. While admittedly more vague and perhaps more difficult to implement, at least in the early stages of developing a system, this recommendation nevertheless, is a key issue and deserves consideration. What do institutions hope to accomplish through connectivity? At one level, they intend to make what is already available, like applications programs, more readily available. But at a higher level, the aim is to promote more effective use of knowledge. The rapidly expanding knowledge base seems always ready to overwhelm, and individuals find themselves forced into narrower and narrower specializations. A key question now is whether technology can be used to foster the use of knowledge. Can expert systems, for example, be developed to scan a vast area and reduce it to its essence in some area of interest? The integrated campuswide network that provides access to all resources provides a necessary tool for enhancing the use of knowledge. The challenge is to find sufficient means.

Develop a detailed plan to start the development and operation of the system. Determine what strategy is best, given local circumstances, to address users' needs and to involve faculty and staff. This recommendation involves beginning development in a manner that ensures the most effective initial implementation and quickest total involvement. C kson University, for example, decided that its engineering school was best suited to lead the introduction of microcomputers into the curriculum, but in a more comprehensive institution, it might not be as effective. Engineering faculty and students are assumed to have skills in computing, and those in history or philosophy might not see the relevance of engineering computing to their own work. Depending on the circumstances, the better strategy might be to begin with the philosophy department. In any event, few institutions will have the resources to implement a campuswide computing system in a short time. It will be necessary rather to develop it in phases, but a clear strategy is needed for the order in which phases develop and organizational units are involved.

Judgments

There is little doubt that profound change is indeed under way. But how is postsecondary education also faced with profound challenge?

To answer this question, we must go beyond our data. Our fourth assumption extends to higher education a responsibility for helping to ensure a positive use of knowledge, and the networked campus with total access to resources provides a new and special tool for the use of knowledge.

The jury is still out on the final effects of the scientific discoveries of the past 400 years, and we have all seen in science the potential for great good and great evil.

> *Science and engineering have been the catalyst for the unprecedented speed and magnitude of change . . . . But science and engineering have been unable to keep pace with the second-order effects produced by their first-order victories. . . . Of what we are doing to our progeny, we still*

have only ghastly hints. . . . We have learned how to transform prairies into dustbowls, lakes into cesspools, and cities into mausoleums. Can we turn around before it is too late? (Weinberg 1975, p. 2).

The major problem, in Weinberg's view, is to bring the power of knowledge under control. Similarly:

The difficulty is that our machine technology and our scientific methodology have reached a high pitch of perfection at a moment when other important parts of our culture, particularly those that shape the human personality—religion, ethics, education, the arts—have become inoperative or, rather, share in the general disintegration and help to widen it (Mumford 1973, p. 480).

For the first time, we have the ability to bring human history and perhaps all life on this planet to an end.

While most of us would like to think of such comments as overstatements, we note with increasing anxiety the reports on the greenhouse effect, the holes in the ozone layer at the poles, the elimination of species, and general damage to the ecosystem. All of these effects can be attributed in one way or another to the power that knowledge gives to alter the environment, and we are faced with the unfaceable: Humanity indeed has the knowledge to end human life on this planet. All of us would suffer the consequences if such a dire event came to pass, and therefore none of us can escape responsibility for bringing under control the power given by knowledge. It is in this sense that the information revolution presents profound challenge.

The use of knowledge, considered in this light, is the greatest of concerns. It is far beyond our old analogies of the links provided by the agricultural extension agent and the drug detail man. It is a matter of whether science and the knowledge it produces can be made to work for the good of human kind and not for its destruction.

We hope that our readers have learned something of practical value in planning for the use of microcomputers. We also hope that they have become aware of greater possibilities and of greater consequences.

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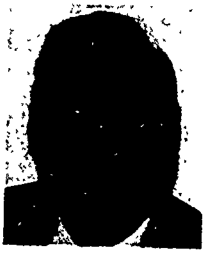

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