DOCUMENT RESUME

ED 214 446 HE 014 898

AUTHOR	Masat, Francis E.
TITLE	Computer Literacy in Higher Education. AAHE-ERIC/Higher Education Research Report No. 6, 1981.
INSTITUTION	American Association for Higher Education, Washington, D.C.; ERIC Clearinghouse on Higher Education, Washington, D.C.
SPONS AGENCY	National Inst. of Education (ED), Washington, D.C.
PUB DATE	81
CONTRACT	400-77-0073
NOTE	63p.
AVAILABLE FROM	American Association for Higher Education, One Dupont Circle, Suite 600, Washington, DC 20036 ($4.00, members; $5.50, nonmembers).
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Basic Skills; College Administration; College Curriculum; College Faculty; *College Planning; *College Students; *Computer Assisted Instruction; *Computer Literacy; *Computer Science Education; Continuing Education; Federal Aid; General Education; Global Approach; Government School Relationship; Higher Education; Information Systems; *Microcomputers; Program Costs

ABSTRACT

Computer literacy in higher education and its relationship to computer science and other areas of the institution, such as general and continuing education, are considered, along with issues related to academic and administrative aspects of computer literacy. The impact of microcomputers is assessed, as is the extent to which computer science and literacy are increasing in other countries. It is suggested that given the continuing success of computer literacy at the elementary and secondary levels, computer literacy in higher education could, in time, acquire the status of a basic skill. Curricular concerns include the advantages and disadvantages of computer assisted instruction (CAI), the relationship of microcomputers to CAI, and who should be computer literate. According to the literature, computer literacy is intended for everyone, and the literacy level that is effective at one institution may be inappropriate at another, although common characteristics are indicated. Important administrative considerations are the issues of facilities planning, the acquisition of computer literate faculty and staff, and the cost of providing literacy to students, faculty, and administrators. In brief, the relationships among goals of students, faculty, and staff members and the relationship of these goals to resource support are determining factors in the planning, development, and implementation of computer literacy programs. Issues and problems of national scope that require national strategies for their resolution include: networks, national databases, federal support of computer education, national cooperation and coordination, and international competition. The state-of-the-art in computer literacy practices and research is reviewed, and a bibliography is appended. (SW)

Report **6** 1981

Computer Literacy in Higher Education

Francis E. Masat

AAHE

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AAHE-ERIC/Higher Education Research Report No. 6, 1981

Prepared by

ERIC®

Clearinghouse on Higher Education
The George Washington University

Published by

AAHE

American Association for Higher Education

Cite as:
Masat, Francis E. *Computer Literacy in Higher Education.* AAHE-ERIC/Higher Education Research Report No. 6, 1981. Washington, D.C.: American Association for Higher Education, 1981.

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This publication was prepared with funding from the National Institute of Education, U.S. Department of Education, under contract no. 400-77-0073. The opinions expressed in this report do not necessarily reflect the positions or policies of NIE or the Department.

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Acknowledgments

The author gratefully acknowledges the support of the director, staff, and editors of the ERIC Clearinghouse on Higher Education. A special thank you is extended to Alan B. Donovan of Glassboro State College and Peter Patton of the University of Minnesota for offering materials and valuable suggestions.

Foreword

One of the major new themes in higher education is the expansion of computer science and its application in practically every field of endeavor. Understanding and knowing how to use a computer—computer literacy—has become a fact of life for millions of students entering institutions of higher education. Because of the increasing level of sophistication that students now bring to higher education, because of the availability of computers at both the elementary and secondary levels, and because of the necessity to integrate the use of computers in all disciplines, it is now imperative that the faculty, especially the older faculty, become more informed in the use of computers.

This Research Report by Francis E. Masat, associate professor of mathematics and computer science and special assistant to the president at Glassboro State College, examines the issue of computer literay. The report is organized around five areas: computer literacy in higher education and its relationship to computer science, the use of computers in education, including the impact of microcomputers; academic considerations such as curriculum, general and continuing education, instruction, computer assisted instruction, and staffing issues; administrative concerns such as the planning, costs, and development issues associated with computer literacy, and national issues such as networks, data bases, privacy and security, and the role of the federal government in computer literacy.

This literature review is designed to help faculty and administrators identify the constraints to the development of computer literacy programs and devise steps to eliminate these constraints.

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Overview

Computer technology and literacy are two of our nation's most important resources. With about half the labor force holding information- and computer-related jobs and earning more than half the labor income, information has become our major national commodity. Moreover, our society has become irreversibly dependent on computers, particularly in the areas of business, energy, space exploration, research, and national security. Our ability to use computer technology thus contributes significantly to our nation's present and future intellectual and economic strengths. For colleges and universities, computer literacy is increasingly needed for research and development, for efficient and effective management, and for the use of sophisticated technological equipment.

National associations and professional societies have been studying and promoting computer literacy for many years. But only recently, with the impetus provided by inexpensive microcomputers, has computer literacy begun to appear on many college and university campuses. Academe is focusing increased attention on computer literacy—what it is and who it affects Since most computer-related education is now occurring at precollege levels, a review of the status, issues, and trends in computer literacy relative to higher education is appropriate and timely.

The impact of the unpredicted surge of computer use in elementary and secondary education is only just beginning to be felt by higher education. With computer use now found at all educational levels and in a growing number of activities, the resulting expansion of information and data is nearly too large to comprehend. Although curriculum appears to be the major issue, many other complex issues are involved. staffing, resources, ethics, security, management, and the structure and nature of learning and teaching with computers. New policies and flexible procedures are needed if higher education is to meet the staffing and resource problems created by the national demand for computer personnel. And with the demand expected to continue well into the 1990s, institutions of higher education are eager to capture as much of the student market as they can, it is a matter of survival for many schools

What does computer literacy mean for higher education? What are institutions doing in response to computer technology? This monograph synthesizes the results of previous studies and integrates new material gathered through the spring of 1981. It analyzes materials from literature searches, major papers from the 1980 and 1981 National Computer Conferences and from the newly established National Educational Computing Conferences, and from unpublished sources. Included are exemplary results and trends that offer background and perspective on how a campus may respond to the issues involved.

Local and national issues usually overlap. Often, within a state or region there are severe disparities in access to computers and computer literacy. When these are translated into economic and educational advantages, local issues take on national impact. Conversely, the national concerns of defense, telecommunications, and regulation affect local networks, data bases, and the creation and use of software. Where possible national issues are separated from those being addressed on local campuses. Similarly, distinctions are made between computer use and user and between computer assisted instruction (CAI) as curriculum and as instruction.

This monograph is divided into seven chapters Chapters 2 and 3 center on computer literacy in higher education and its relationship to computer science and other areas of the academy, such as general and continuing education Among the questions considered are. What is computer literacy? What are the implications of precollege computer education? Where will computer literacy be used? What is the curricular place of computer literacy? The impact of microcomputers is assessed, as is the extent to which computer science and literacy are increasing in other countries. The findings indicate that microcomputer use and the demand for computer literacy will continue to increase. The findings also provide perspective on the pervasiveness of both computer literacy and use. Nationally, computer literacy is a societal requirement that is not being met by many institutions. Given the continuing success of computer literacy at the elementary and secondary levels, computer literacy in higher education could, in time, acquire the status of a basic skill.

Chapters 4 and 5 review the issues and considerations attached to the academic and administrative aspects of computer literacy. Curricular concerns discussed include the advantages and disadvantages of CAI, the relationship of microcomputers to CAI, and who should be computer literate. The literature at this point is consistent. Computer literacy is intended for everyone, further supporting the earlier notion that computer literacy is either a part of general education or a basic skill. Moreover, the literacy level that is effective at one institution may be inappropriate at another, although common characteristics are indicated. Whether computer literacy is treated a a new curricular or academic area, as a basic skill or competency, or as part of general education, is not as important as the fact that an increasing number of students are entering college with a smattering of computer science and a demand for more Although higher education must respond to the computing needs of its constituencies, many institutions as yet do not have the commitment, faculty, or resources needed to do so. In fact, institutions that have not entered the computer age may be too far behind the trend to survive.

Foremost among the administrative considerations are the issues of facilities planning, the acquisition of computer literate faculty and staff, and the cost of providing literacy to students, faculty, and administrators. Faculty and staff reallocations are being based on new responsibilities and tasks. And networks of microcomputers are causing computer center functions to be restructured. In brief, the relationships among the goals of students, faculty, and staff members and the relationship of these goals to resource support are determining factors in the planning, development, and implementation of computer literacy programs.

Chapter 6 focuses on issues and problems of national scope that require national strategies for their resolution networks, national data bases, federal support, national cooperation and coordination, and international competition The literature indicates that, nationally and internationally, industry and business will continue to move ahead of education in computer use and development. This monograph discusses such questions as.

- Will training and continuing education provided by industry and business supplant that of higher education?
- Is intervention necessary in those states where little or no computer literacy is evolving?
- Who has national responsibility for computer literacy?
- What societal impact will literacy have?

Until the federal government is ready to support either early or college-level computer education, higher education associations and professional societies must continue to bear this responsibility.

Chapter 7 completes this monograph with a summary of the findings, an assessment of the state-of-the-art in computer literacy practices and research, and conclusions on those policy and value questions that will remain as computer literacy continues to evolve. No one is yet able to predict with any certainty the effects or extent of computer literacy, much more research remains to be done. With robots, home computers, and an emerging cable television and videodisc industry, the evolution of computer literacy is constant; new applications and implications emerge almost daily. All this suggests that computer literacy and the use of computers is leading us into the unknown. Clearly, this suggestion is replete with existential and societal overtones, in part because, although computers are benign, those who control them may not be. Thus, a concluding theme of later sections of this work is that computer literacy will become increasingly necessary for effective participation in a free society.

Computer Literacy: Some Perspectives

Computer literacy is not defined in our dictionaries, yet it has an immense and far-reaching influence on nearly every facet of our lives. Generally defined as understanding a computer and being able to use one, computer literacy continues to evolve as educators and lay persons alike struggle to sort out what computer literacy includes and what includes computer literacy.

Nationally, the discussion continues over what it means to be computer literate. According to various authors (Johnson et al. 1980; Klassen et al. 1980; and others) computer literacy:

- imparts knowledge about handling information
- dispels fears and myths associated with computers
- develops skills in using and programming a computer
- develops procedural learning
- addresses the ethical and societal issues raised by computing

At its root computer literacy requires a commitment to learning about and with computers. Most important it requires learning the art and science of putting your thoughts to work by using a computer. In a fundamental sense, computer literacy ranks with the three R's in importance to Western society.

> *At the abstract level, computer literacy presents few problems. It is an honorable goal with few negative connotations. It is seen as providing a basis for improving national productivity and the well-being of all citizens. It is one of the cornerstones of a society built on technology. It is, according to some, necessary for survival. Like motherhood and apple pie, it is difficult, perhaps even un-American to oppose computer literacy (Klassen 1981, p. 66).*

The Carnegie Commission on Higher Education published a report in 1972 entitled *The Fourth Revolution.* This title comes from Eric Ashby's observation that there have been four great educational revolutions. The first occurred when the education of the young shifted from parents and home to teachers and the school. The second revolution occurred when the written word was adopted as a tool, and the third happened when printing was invented. The fourth revolution, which concerns us most, was created by electronics, in particular, the development of radio, television, and computers. Many in education view the computer as the imperative of the fourth revolution (Molnar 1973).

Computer Literacy in Higher Education

Several associations and commissions have studied the use of computers in higher education. The President's Science Advisory Committee concluded that if educational computing is to find a useful place in colleges and universities, course material in the various disciplines will need substantial revision (National Science Foundation and Department of Education 1980).

This statement was reiterated by the Carnegie Commission on Higher Education, the Commission on Instructional Technology, and others. Many reasons have been cited for using computers in higher education, foremost among them. the individualization of instruction, a means for educational reform, emphasis on analysis, and more quality material available to more people (International Federation for Information Processing 1974, pp. 8–9). Expressed in broader terms, these are the issues of computer assisted instruction (CAI), management informations systems (MIS) and their use in higher education, faculty and student research, and the distribution of computer software.

The emerging issues of privacy and security cast a shadow over all these (Hussain 1978, Logsdon 1980). Such concerns, however, do not detract from the fact that the introduction of computer literacy courses for students, faculty, and administrators alike is justified by the contributions computers have made and are capable of making to education (Leepson 1981, Worthy 1977) "A fairly rudimentary understanding of data banks, programming, and information retrieval systems will make it far less likely that educated men and women will, in the future, be over-awed and cowed into intellectual submission by mere printouts" (Sawhill 1980, p. 14). Moreover, the need to understand computers and their uses does not stop with students, faculty, or administrators. At a seminar for boards of trustees sponsored by the Association of Community College Trustees and the San Diego Community College District, the following key conclusions were developed:

- The most important task is determining what role computing presently is playing and what the projected needs for the future are.
- Trustees must recognize the overall importance of an efficient computing resource to the success of the institution.
- Trustees must be knowledgeable enough about computers to ensure that the institution receives a proper return on every computing dollar invested.

In response to the growing numbers of jobs calling for the ability to work with computers, secondary schools are producing students who understand computers and their applications (Taylor 1981). This development has long range implications for postsecondary institutions. Adults are returning to the campus to take computer courses or to learn about recent advances in computers and computer applications. Although more colleges and universities are requiring computer-related or computer literacy courses, the majority of higher education classes do not yet reflect the tremendous opportunities provided by computer technology. Thousands of entering students have used computers throughout their educational careers, and for these students, the computer is not a tool to be put aside when they enter college. Rather, it represents the capability to make rapid computations and to reason, recall, and amend and the opportunity to explore and create.

Rapid change is occurring as more educators are asking not whether computers will enter classrooms, lecture halls, and labs, but rather:

- At what rate will microcomputers enter the classroom?
- How can decision-makers select the most appropriate systems?
- What is the best way to train teachers to use CAI?
- How do we (or should we) build on the informal contact students may have with microcomputer systems?
- What evaluation methods are required to assess the effectiveness of computers in the classroom? (Braun and Aiken 1980, p. 16).

One primary function of computer literacy is to dispel the fears and misapprehensions that have accompanied the growth of computer knowledge. A major misconception is that computers are a part of mathematics. Although mathematical skill is certainly useful to someone making extensive or programmatic use of a computer, mathematicians are not the only ones who use computers. They are being used more and more in such areas as music, television, education, business, government, art, history, literature, remediation, and biology. Art and music students are using computers as creatively as mathematics students, perhaps more so (Van Loan 1980). In fact, mathematical research has not been affected significantly by the computer Although the computer has allowed mathematicians to make computations that previously would have taken them years, it has not created new mathematical theories.

Some students and faculty will be frightened when they first confront a computer system. The need to feel competent and to avoid mistakes permeates all other considerations. Learning by doing, however, is of primary importance in learning to use a computer. Although an individual's emotions may get in the way of learning, the computer's will not. Even the youngest users quickly realize that computers do not get angry when a mistake is made.

Computer Science and Literacy

A computer literate person is somewhat akin to a computer scientist: A computer scientist usually is involved in creating and developing computers, software, and applications; a computer literate person usually is a user of computer technology or of applications of computer technology. However, being one does not automatically qualify an individual for the other. For example, some computer scientists do not know the first thing about telecommunications, business applications, management information systems, or many of the newer uses of microcomputers.

By convention, the term "computer science" serves as shorthand for "computer science and data processing." Although "computer science" is the accepted term at the university level (with "information science" used occasionally), both "computer science" and "data processing" are used at the four-year college level and "data processing" is used more commonly at the community college level (Ralston 1981, p. 9).

Many computer science departments have begun to provide computer-related education for non-computer science majors (Hunder 1980, p. 5). Also, in some instances, introductory computer science courses are tailored to meet the needs of varying disciplines or major fields. Such courses provide at least some degree of computer literacy.

Much of the demand for computer literate graduates presently is being met by computer science graduates. We can extrapolate estimates of the need for computer literate graduates by inspecting the demand for computer science graduates. Based on sources such as the yearly reports on the supply and demand of Ph.D's in computer science compiled by Orrin Taulbee of the University of Pittsburgh and Sam Conte of Purdue University (Conte and Taulbee 1976–1980), the manpower data compiled periodically by Information Systems Consultants (Hamblen 1973, 1975, and 1978), and projections by state departments of labor statistics, some estimates can be made. For example, it is estimated that in 1980 there were 12 jobs available for every bachelor's degree graduate in computer science and 34 positions for every Ph.D. in computer science. Clearly, the demand far exceeds the supply (Magarrell 1981b, p. 3). And, according to Anthony Ralston of the State University of New York at Buffalo:

> *The yearly deficit caused by the failure of colleges and universities in the United States to produce as many graduates at all levels as there are jobs assures that the demand for graduates will remain strong for years after the explosive growth of the computing industry itself has leveled off (Ralston 1981, p. 9).*

Computer Literacy as a National Resource

The inexpensiveness of microcomputers and their popularity with consumers has significantly heightened national awareness of computing. Computer literacy has become as much a societal issue as an academic one (Logsdon 1980; Houser 1977). Moreover, as computers are developed that conduct dialogues with people on whatever level of computer literacy they possess, the term "computer literacy" is becoming a relative one. Clearly, computers, both as tool and as medium, offer alternatives that can significantly affect the availability, quality, and level of education. At the same time, it should be understood that there will continue to be individuals who have neither the desire nor the need to be computer literate.

The May 1978 *The Mathematics Teacher* published a position statement on "Computers in the Classroom" prepared by the Instructional Affairs Committee and approved by the board of directors of the National Council of Teachers of Mathematics:

> *. . . an essential outcome of contemporary education is computer literacy. Every student should have first-hand experiences with both the capabilities and the limitations of computers through contemporary applications. Although the study of computers is intrinsically valuable, educators should also develop an awareness of the advantages of computers both in interdisciplinary problem solving and as an instructional aid.*

The preceding statement illustrates two major points. First, computer literacy is not the sole province of mathematics, or of business for that matter, and second, it is very easy to drift off into enumerating "shoulds" when discussing computer literacy. There are, however, certain areas of computer literacy that *are* pertinent to all educated persons:

- the societal impact of computers
- the applications of computers
- an understanding of and experience with computing techniques and the concept of a stored program, process, or procedure
- the rudiments of data storage and the abuses to which computers can be put

Note that these items correspond to the aspects of "knowledge about" and "skill with" computers. Moreover, three critical issues affect these four areas: the depth or level of literacy programs, the effectiveness of instructional programs, and the disparity of access to literacy programs and computers. These issues may remain unresolved for a number of years. Although a few states, most notably Minnesota (Rawitsch 1981), have shown that these issues can be overcome by state policies governing the implementation of computer literacy, the majority of the nation's elementary and secondary students are receiving superficial computer training or none at all.

The problem is being perpetuated because there is at present no nationally based computer education curriculum that spans elementary school through college, or, for that matter, one that spans kindergarten through high school. Computer literacy curriculum is still in its infancy. With the rapid growth of computer technology and software, the amount of learning necessary to remain current increases yearly; development is exceeding the rate at which students and society presently are learning. However, those schools with computer education curricula are producing citizens who de facto will be more adaptable and employable than those with no computer education.

As the United States increasingly becomes an information-oriented society, a computer literate populace is as important as energy and raw materials. The nation's capital is currently as much scientific knowledge, computer science in particular, as it is natural resources (Molnar 1979, Magarrell 1981d). In 1979 Andrew Molnar noted that:

> *There is a national need to foster computer literacy... A nation concerned with its social needs and economic growth cannot be indifferent to the problems of literacy. If we are to reap the benefits of science-driven industries, we must develop a computer literate society (1979, p. 283).*

Without some form of computer literacy, many people will be left out of present and future job markets. These people, who are often higher education students, in turn will be left out of future social, government, and leadership roles. According to John Sawhill:

The ability of our graduates to make vital social and business decisions will be seriously impaired if they do not understand the possibilities and limitations of this new technology. Worse, they will find themseives in the clutches of "experts," too intimidated to dispute the wisdom of the machine (1980, p. 14).

With the growing number of computer users, the following findings illustrate the magnitude and complexity of the emerging educational issues and problems. Although stated as general needs, they make clear the implications for computer education—especially the need for students to become computer literate before they get to college.

- There are shortages of trained computer professionals at all degree levels.
- The current shortage of trained computer professionals at all degree levels is expected to persist beyond 1990.
- Minorities, women, and the physically handicapped continue to be underrepresented in the profession.
- There is an immediate problem of providing for the acquisition, retention, and maintenance of high-quality faculty to teach computer literacy and computer science courses.
- The high cost of maintaining existing equipment and of replacing obsolete machines is a severe problem for many university faculty.
- Decreasing interest is being shown in science and mathematics courses in U.S. secondary schools, in marked contrast to the trend in many European and Asian countries.
- There is a notable absence of coordination among the components of computer education and computer science, particularly between the secondary and college levels.

Other studies (Ralston 1981, Hamblen 1979; National Science Foundation and Department of Education 1980) indicate that computer instruction, computers, and information services will proliferate well into the late 1980s and early 1990s.

The Growing Use of Computers in Education

As early as 1967, 46 percent of the Gross National Product was produced by information industries, and nearly half the labor force held information-related jobs. By 1975, professional and technical persons composed the second largest of eight occupational divisions, exceeded only by semiskilled workers (Molnar 1979, p. 277).

Computers are now found in General Motors automobiles, in hospital diagnostic equipment, in airport control towers, and in word processors. They are being used to write movies, diagnose athletic styles, generate music and poetry, control stage lighting, and catalogue and simulate practically anything.

Recent advances in computers include:

- office machines that identify misspelled words in six languages
- advanced dictating machines that act on instructions from a telephone anywhere in the world
- computers that edit and analyze the writing quality of technical manuscripts
- computer software that simulates operations for medical students and courtroom situations for law students
- computer voice synthesizers that translate languages or read books aloud

The largest single user of computers in the United States is the federal government, which has 10,000 computers and spends approximately $10 billion a year on equipment and personnel (Molnar 1979, p. 281). Computers and computer literacy have become indispensable to government, particularly in defense and research.

Today, the National Center for Education Statistics estimates that there are more than 50,000 computers being used in educational computing. The state of Minnesota, for example, uses more than 4,000 microcomputers and on-line terminals for instructional applications (Rawitsch 1981, p. 454).

Computer simulation has been one of the most useful and productive activities in education (Roth 1976). More fundamentally, computers provide an appealing and effective means for educationally disadvantaged students and adults to obtain the basic skills (Mason and Blanchard 1979; Taylor 1981). According to Robert Taylor (1981, p. 8), through the use of a text editor, "the student internalizes the concept of writing as an extended process and escapes from the misleading and unproductive view of writing as the generation of a single draft."

Computer Uses in Higher Education

Characteristically, computer activity in higher education falls into three main types (Schouest and Thomas 1978). data processing, as defined by the need to store and retrieve large and often complex amounts of data, scientific analysis, and software utilization, as defined by needs in social science, administration, the humanities, and educational technology.

There are four major groups of computer users in higher education: administrative, research, instructional, and student.

Administrative uses. Computer use is growing most rapidly in administrative areas. As Robert Gillespie has noted:

> *The most rapidly increasing use of computers in higher education is in administrative applications. Recent studies by Dr. John Hamblen show that funding for administrative computing jumped from 34 percent of total computer allocations in 1969/70 to 45 percent in 1976/77; thus the percentages for instruction and research have declined (1981, p. 174).*

Administrative usage is increasing because of new demands for comprehensive student data: financial, demographic, and academic data on *every* student—from preapplicants through graduate and continuing education, both full-time and part-time. Typically, admissions, financial aid, registrar, advising, counseling, accounting, veterans' office, housing, and planning and research are increasing their demands on the campus computing facilities (McLaughlin, Montgomery, and Mahán 1978; Stamen 1979; Klein, Thomas, and Netter 1979; Wetherbe and Dock 1978; Wise 1979).

A few exemplary uses are found in registration and record-keeping applications. Central Washington University, for example, uses 20 computer terminals to schedule 10,000 students over two days, with a registration rate of six students per minute. Students do not interact with the terminals, rather, a secretary or terminal operator, with as little as 15 minutes of training, handles the data entry and results. The total one-time cost of the complete system paid for itself in less than three years (Clark 1978, pp. 468–70). Other institutions are adopting similar operations.

Computers also are being used by admissions offices, not only for letter writing, awards, record-keeping, and screening, but also for recruiting. Colleges are increasingly advertising the use and availability of computers on their campuses. "Computer literacy," "micros," and "on-line time" have become the new trade words of college recruiting sessions and brochures.

By taking advantage of data banks, computerized information storage and retrieval, and word processing, administrative and departmental offices are enhancing the speed, accuracy, and quality of their services. The influx of terminals and microcomputers into the offices of presidents, deans, office managers, and supervisors clearly signals that the age of computer literate administrators in beginning. Moreover, one of the recommended agenda items for the American Council on Education's recently formed National Commission on Higher Education Issues calls for "making higher education more responsive to computer usage, telecommunications, microprocessing, and generally increasing and rapid change in technological developments" (American Council on Education 1981).

Student uses. It is useful to place student-users into three categories: computer majors, information science majors, and others. According to Hamblen's most recent survey of American educational computing, more than 90 percent of students fall into the "other" category (Hamblen 1979). Because of this, many colleges and universities have integrated computer literacy into their curriculum and more are following suit. At Dartmouth College, the computer is considered to be as important to the student as the library, Dartmouth students are permitted to use the computer, free of charge, any time of day, for any reason. A similar scheme is practiced by the eight state colleges of New Jersey as well as by many other institutions across the country.

At Northern Illinois University, more than 4,000 students use computer terminals in laboratories set up for that purpose around the campus But about 100 students do their computer work on their own terminals without leaving their apartments or dormitory rooms (Magarrell 1981a, p. 14).

Students now use computer-assisted text preparation for everything from theses and legal briefs to term papers and poetry, some submit their work on computer discs (computer storage devices). If Richard Cyert, president of Carnegie-Mellon University, has his way, in five years all students at the university will be required to have their own computer (Magarrell 1981a, p. 1). Although this may seem a little extreme, a growing numb of institutions are requiring computer literacy for graduation. Most rec nt among these is Hamline University (Associated Press 1981).

The use of microcomputers by students will continue to evolve. Nowhere else in higher education is there occurring an evolution of such unknown consequence and duration.

The Role of Microcomputers

In general, the widespread use of computers has been due to the rapid expansion and acceptance of microcomputer technology. Microcomputers are small computer systems—self-contained desktop units—that have the same components as larger computers, but usually cost much less, use fewer languages, have less memory, and require less time for maintenance or repairs. With impetus from the space program, microcomputer systems were first marketed in the mid-1970s. Estimates of the number of micros range from 60,000 at the end of 1979 to more than 1.5 million by the end of 1981. In terms of impact on society, education, and business, perhaps no tool in our history has had such a powerful and far-reaching effect as the microcomputer (*Educational Technology* 1979; MECC 1979, Evans 1980; Osborne 1981; Rawitsch 1981; Craig 1981).

The evolution of the microcomputer and microprocessor has enabled computers to be used in a growing number of educational applications and social settings. The literature repeatedly shows that microcomputers are more accessible to students and professors than larger systems (Price 1978, Zinn 1978; Gillespie 1980; Chambers and Sprecher 1980). Moreover, the portability, minimal maintenance, and capabilities for color displays, high resolution graphics, and text processing make them ideal tools for practically everyone on campus. Their greatest asset, however, appears to be in developing widespread computer literacy (Eisele 1979). Microcomputers have been used predominantly in the classroom and laboratory, particularly to teach basic skills, to analyze data, or to manage tutorials (Doerr 1979). Now, however, they are found on the desks in the financial aid, security, athletics, admissions, and maintenance offices. Although these offices have in some cases been able to use computers in the past, it was usually on time-sharing and batch processing systems, microcomputers now enable deans, faculty, secretaries, and students alike to use word processing and data entry and management in making needed changes.

Faculty response to microcomputers, however, is mixed. This is natural, since higher education is now staffed with a generation not oriented to computers. The situation is changing, however, because a large number of entering students have worked firsthand with microcomputers in their schools, homes, clubs, or workplaces. Microcomputers, with their usefulness in homes and schools, are making converts.

With both hardware and software design continuing to improve, microcomputers are replacing larger systems for many tasks. Unfortunately, software suitable for large systems cannot be used in microcomputers, and software developed by one brand of microcomputer often cannot be used in another. Nationally, software firms and universities are working to solve these incompatibility problems and to adapt existing software so that it may be used on more than one system. Although programs are being written that will translate one computer language to another, it does not appear likely that the software industry will adopt one standard language for educational software. Locally developed or adapted materials will still be those used most frequently.

The International View

Following a 1980 trade mission to China, John Craig wrote in a January 1981 issue of *Infoworld* that the People's Republic of China appears to be about five years behind the United States in computer development and use. Some Chinese universities, however, have purchased a variety of American microcomputer systems for computer science courses and development work (Craig 1981, p. 24). Moreover, J.A. Jordan, Jr., of the Asian Institute of Technology (AIT), claims that:

> *computing in Asia is growing more rapidly, on a percentage basis, than in any other part of the world. . . . Because Asia is just at its dawn of computing, there is a dearth of the self-trained data processing people who form the backbone of the user community in the developed countries. . . . Now, in response to the needs of Asian computer users, AIT is initiating programs in computing education (Jordan 1980, p. 11).*

The situation in Japan is different because Japan already has entered into direct and successful competition with the United States, particularly in the microprocessing area. The U.S. Department of Commerce reports that West German, French, and British computer firms also will offer competition in the near future. Moreover, UNESCO has shown interest in computing curricula for developing nations*, France has ordered 10,000 microcomputers for its schools, and England recently spent £9.5 million on computer educational projects (Atchison 1981). At a recent international conference, 35 papers, representing computer applications in art history, archaeology, architecture, archival cataloguing and indexing, art bibliography, art theft detection, and iconography, were presented by researchers from 13 countries (*Computers and the Humanities* 1980, p. 113). According to Molnar, "statistical indicators show that the United States is fast being overtaken in innovation of new technologies by more dynamic foreign economics" (Molnar 1979, p. 278). Evidence shows that these countries are investing in the research and development of computer-based education and industries. An unanswered question is whether the United States will make the same commitments, particularly to postsecondary computer education.

*For an indication of administrative computing in developing countries, see Wilson (1977).

Academic Considerations

Curricular and Developmental Issues

For whom is computer literacy intended? What constitutes a computer literacy curriculum? What is the place of computer literacy in the curriculum? How does computer literacy mesh with basic skills, general education, and two-year college curricula? The issues are complex and tightly interwoven. If not required of all students, should computer literacy be a part of every curriculum? If computer literacy is a basic skill, should it be obtained before enrolling in general education courses? The answers are still evolving.

Who should be computer literate? The answer varies, but the literature reveals a growing consensus that by the secondary level every student should acquire some computer literacy (National Council of Teachers of Mathematics 1978; Molnar 1979; Klassen 1981). A growing number of universities and colleges agree with this idea and have implemented a computer literacy requirement. In fact, the trend is toward requiring computer literacy of all students. Nationwide, colleges and universities are also reaching outside the academy to implement computer literacy through continuing education workshops, management and faculty workshops, teacher training institutes, regional computer science contests, and similar activities. An interesting example is Johns Hopkins University's nationwide contest, concluded in June 1981, to inspire new inventions that apply computers to the needs of handicapped individuals.

Robert Gillespie (1981) claims that national needs for general competency in computing currently fall into three categories:

> 1. *educational requirements, so that all students have a basic understanding of computers and how to use them*
> 2. *industrial training in conjunction with university curricula to meet the growing demand for competent personnel in all aspects of computing*
> 3. *computer literacy for the general public, which would include assessing the computer's impacts on society and publicizing these issues (p. 173)*

Statistically, computer literacy is intended for the general public and the majority of computer users (Schimming 1980). The inherent problem in providing computer literacy only to computer users is that it separates those working with computers from the rest of society. Based on this and other similar observations, Andrew Molnar urges that "if we are to have equity in our educational system, all students must have access to computing and must become [computer] literate" (1979, p. 280). Molnar adds that "a student who graduates without being exposed to computers has had an incomplete education." Furthermore, computer literacy is not confined to college or high school. Seymour Papert of M.I.T. conducted computer-learning experiments with elementary school children and found they could use the computer to solve complex problems in physics, geometry, and physiology and that they also were capable of generating music and poetry (Papert 1980).

Carrying this one step farther, some authorities (Zinn 1978; Atchinson

1981) argue that computer literacy is the individual's responsibility, one that can and should be fulfilled either before going to college or strictly outside regular classes.

What is to be taught? If the present national movement toward providing computer experience for all precollege students continues to its conclusion, the question of who should be computer literate at the collegiate level becomes moot. Until then, the issue of computer literacy centers on what is to be taught and how it should be integrated into the curriculum. Thus, there is an emerging need to consider a computer literacy curriculum that spans elementary through college levels. In the process of creating such a curriculum, national in scope, criteria need to be developed for each level. As computers are integrated nationally into the various levels of primary, secondary, and college curricula, the literacy needs of entering students will shift to match their backgrounds. Thus, there is no consensus on precisely what constitutes a basic course in computer science, nor in computer literacy. Yet, some general and majority views are available (Austing et al. 1979; Johnson et al. 1980).

Generally, computer literacy courses are suitable for those who will not normally be taking any further computer training and for those oriented to careers or occupations outside computing. The thrust of such courses is to provide understanding and knowledge of computer systems, including:

- computer organization, including microcomputers
- procedures and algorithms for processing information
- a history of computing and computers
- a hands-on experience
- capabilities and limitations of computers
- present and future uses of computers
- a perception of the societal impact of computers
- the potential threat of computer abuse

By comparison, an undergraduate degree program in computer science (see Austing et al. 1979, p. 149) aims, at the very least, to instill in its students.

- the ability to write computer programs
- the ability to determine whether a program is reasonably efficient and well organized
- knowledge of the types of problems amenable to computer solution
- understanding of basic computer architecture
- preparation for further computer science training

Computer literacy courses are not computer science or computer programming per se, although a first course in computer literacy will usually include simple programming experiences. In fact, learning a computer language, if only the rudiments of one as simple as BASIC, prepares one for new and expansive learning experiences.* The task of programming a computer becomes a linguistic one: analysis, synthesis, semantics, logic, sequential reasoning, and punctuation. Computers either understand you or they do not. Cause and effect takes on dynamic and immediate meaning, what you do makes a difference. Clarity and precision are necessary when you are communicating with a computer; rigid adherence to syntax is the rule. In fact, some authors claim that a person's experience with computers will transfer to his or her use of grammatical rules (Price 1978, p. 426). Thus, computer programming, and computer literacy in general, is not a hallowed area reserved only for scientists or mathematicians. It may benefit anyone capable of learning it.

Much discussion on computer literacy also centers around the ability of people to move from the "easy" part of computer literacy into the "hard" part. The easy part is learning how the machine works, how it may be used, and how to load and use someone else's efforts. The hard part is using the computer in an original or creative way. This creative process requires computer fluency, not just computer literacy. At this level, individuals come face to face with their ability to think abstractly, to reason logically and chronologically, and to learn, in fact, how to think. Knowledge about computers is stratifying into computer awareness, computer literacy, and finally, computer fluency. The skill levels are not yet clear and may not be until well into the 1980s (Austing 1979).

A number of sources discuss individual courses at length (Austing et al. 1977, Little et al. 1977, Lopez, Raymond, and Tardiff 1977). Several principles apply to the development of computer literacy curricula, particularly in higher education. First among these principles is that of balance between the specific and the general. Computer literacy courses cannot be too skill-oriented or they risk obsolescence and narrowness of application. On the other hand, courses that are too general offer nothing useful in either an intellectual or a practical sense.

Second, computer literacy courses demonstrate current trends in computing and the use of computers. In particular, such courses deal with the growing use and importance of microcomputers, the recognition that programming languages are useful vehicles for the more subtle notions and concepts of algorithmic and sequential problem solving, an awareness of the pervasiveness of computers and the growing reliance upon them in certain sectors of our economy, and the privacy and security issues inherent in an information society. The goal is to know when not to use a computer as well as when a computer may be useful or even necessary.

Third, computer literacy courses maintain a balance between the theoretical and the practical, between education and training. Just as some computer science courses are too theoretical, so too may computer literacy courses become merely training sessions. Enough programming should be

*BASIC (Beginner's All-purpose Symbolic Instruction Code) is an introductory level programming language developed in 1962 and popularized by its use on microcomputers.

introduced to make apparent the concepts of memory, stored data and programs, and the versatility and speed of computers. The amount of programming included, however, should be balanced with all the other topics necessary in such a course.

Computer ethics is beginning to be of national concern. (Wessel 1974; Ellis 1974; and Gemignani 1981). In recent years, many in higher education have become more active in advocating that discussions of the ethical use of computers be included in computer literacy courses (Barstow 1977). Since computer literacy is relatively new, little effort is being put into developing ethical standards for computer use. Presently, software and program copying is rampant; data banks and information records are breached daily. Moreover, even if the ethical issues were clearly identifiable, educators currently lack the appropriate curricular materials to cover these questions in their courses. For the next few years, at least, the first priority of instructors will be cognitive and skill-oriented computer literacy.

The place of computer literacy in the curriculum. The place of computer literacy in the curriculum depends on whether it is viewed as general education, a basic skill, or just another "math" requirement. In the past, social relevance was used to support the addition of computer science to the mathematics requirement that exists at many major universities today. This rationale, besides assuming that practically anything can be justified on the grounds of social relevance, relies on the popular and problematic assumption that computer science, or even computer literacy, is mathematics. It is not. Although mathematics is useful to someone using a computer, language and logic are more useful.

If computer science happens to be in the business or engineering school, then computer literacy can represent new curricular development for them, provided they are interested. Similarly, if computer science is in a mathematics department, then trade-offs can occur between computer literacy courses and mathematics survey courses. But if computer literacy is to be a new addition, then departmental or collegial compromises may have to be made. Moreover, these compromises necessitate changes in resources in addition to curricular changes. Thus, competition is continuing over who owns computer literacy and how best to fit computer literacy courses into an already overcrowded, politicized, and underfunded curriculum. The resulting resource allocation issues associated with computer literacy programs are addressed in a later section.

Where does computer literacy fit into the curriculum relative to basic skills? The Center for Research on Learning and Teaching at the University of Michigan (Zinn 1978), among others, has designed a noncredit course in computer use and programming built around the availability of low cost personal computers. Given that many students enter colleges and universities already knowledgeable about computers, computer literacy, in time, could be relegated to the status of a remedial or basic skill (Hamblen 1978) Given that some topics in computer science, such as following syntactical instructions, reasoning sequentially, and communicating precisely, constitute basic skills, and that computers aid thousands of college students daily in learning to read, write, and compute (arithmetically), what could be more basic than knowing how to use a computer? In fact, many in higher education believe that computer literacy and language literacy can be combined since they are fundamental, intellectually similar, and mutually reinforceable forms of communication (Taylor 1981; Eisele 1979; Murphy and Appel 1977). Analogously, computer literacy calls for varying levels of skills as does language literacy; some individuals can read only one language but others read and write more than one, i.e., computer fluency.

Various educators have noted the lack of computer preparedness in elementary school teachers (Taylor et al. 1979; Henderson 1978; Dennis 1978, the Special Interest Groups on Computer Science Education and Computer Use in Education [Feyer and Moursund 1981, p. 30]). On the whole, teacher training programs neglect computers, even though thoroughly researched and planned curricula exist (Poirot, Taylor, and Powell 1981, p. 18). This compounds difficulties in the student-teacher relationship, because students often have greater computing literacy than their teachers. If computer literacy is to be required of only select student populations, students training to be teachers are an excellent group with which to begin (Milner 1980).

To many in higher education, the importance and pervasiveness of computer literacy, information processing, and computers in our lives justify the inclusion of computer literacy coursework in all college and university curricula. Given that the chief objective of computer literacy courses is to provide students with a knowledge and understanding of computers and computer science at least equivalent to that obtained in music, art, and literature survey courses, then computer literacy courses are, in fact, general education courses. It follows, then, that a knowledge and understanding of computers could be considered as part of that body of knowledge acquired by an educated person. Whether computer awareness or computer literacy will become part of a wider technological literacy is not yet discernible from the literature. Meanwhile, students who are learning how their lives and work are affected by computers and how to use computers clearly have a definite intellectual and economic advantage in the long run, over those who do not.

It appears that the majority of community colleges are, or soon will be, providing computer literacy courses and offering computer programming skills for students majoring in fields outside data processing and computer science (Ralston 1981, Little et al. 1977). Supposedly, two-year colleges have an administrative and curricular advantage over four-year schools since they are responsible for about three semesters of a computer science curriculum. But at many two-year community colleges the computer has entered the curriculum through the technology side. Now business students are taking computer courses as are many students preparing to transfer to four-year colleges. In fact, the components of computer literacy are often scattered across the campus. programming in one department, computer software in an other, and data processing technology in yet a third. Thus, community colleges share some of the same disadvantages and problems as many four-year colleges and universities.

The development of computer literacy programs. Major trends have emerged in the development of computer literacy programs and courses. The pressure of economics and new technologies has caused an influx of students who are interested in becoming computer scientists or at least in acquiring computer literacy. Among these are teachers seeking to retrain and leave their profession, liberal arts graduates desiring enough computing skills to change jobs or get their first job, unemployed individuals who have been displaced because of their outdated skills, and eager high school graduates who want to become "computer programmers." But many entering students are no more prepared to take beginning-level computer literacy or computer science courses than they are to take an elementary grammar or arithmetic course. There is a wide gap between expectations and capabilities.

In addition, preparing coursework is not easy, particularly if it requires integrating computers into existing curricula as opposed to developing a totally computer assisted instructional format. National associations have recently advocated that curricular materials be developed that capitalize on unique characteristics of the computer (Association for Educational Data Systems 1980; Austing et al. 1979; Little et al. 1977). These materials would make possible altogether new instructional experiences, as well as provide creative approaches to existing curricula (Heck, Johnson, and Kansky 1981).

The single most dominant problem in developing a computer literacy or computer science program is that of finding faculty members who are both qualified and interested. There are few incentives to develop programs or write course proposals. Faculty seldom receive promotions, tenure, or even release time based on curricular work. Nor are publishers much help. Surveys show that most publishers are uninterested in developing or publishing computer based materials, particularly in the area of computer literacy (Watkins 1981). However, many hardware and electronics companies have become deeply involved in developing and producing educational materials and workshops and seminars (Foreman 1981). Some college textbook authorities are warning that such firms may, in fact, out-distance higher education both in content and delivery (Watkins 1981, pp. 19–21).

Another major consideration in developing computer literacy or computer science courses is the notion of preparedness. Generally, there is agreement that mathematics courses or courses of a mathematical or logical nature are beneficial as prepartion. Beyond this, however, the results of a recent and extensive study on learning programming show that not much else matters. As Lawrence Mazlack (1980, pp. 16–17) put it:

> *No significant correlation was found between academic performance and academic discipline in either actual program production or in test taking on programming topics.... There is no need to segregate students from different academic disciplines due to concerns based on learning*

ability or interdisciplinary competitiveness... No significant difference was found in academic performance between genders.... The correlations found between semester in school and academic performance were very low.... It is not necessary to construct separate computer courses for those from differing disciplines and levels of academic experience as there is no apparent need to be concerned with unequal capability.

A point worth reiterating is that after taking a first course in computer literacy, many college and university students decide to take another course in computer science. But in this second course problems may occur; students with a weak background in mathematics or an inability to reason sequentially and chronologically often fall beside the way as other more appropriately skilled students succeed. Thus, although college-level mathematics may not be a necessary prerequisite for a typical computer literacy course, mathematics is essential for any student continuing on to a second or third course.

Recognizing that computer literacy courses generally are supported by computer software or computer assisted instructional materials, and cognizant of the myriad of problems involved, the National Council of Teachers of Mathematics (NCTM) researched, developed, and published an important work on evaluating computerized instructional materials that is generally applicable. Their evaluative guidelines are not solely for mathematics or mathematics-related courses, but apply equally to all computer-related instructional materials. In particular, the *Guidelines for Evaluating Computerized Instructional Materials* is one of the first national efforts to respond to the question, "How do you evaluate instructional software?" Prepared under the direction of the Instructional Affairs Committee of the NCTM, this guide is a practical aid for both users and creators of instructional computer software and does not assume programming experience (Heck, Johnson, and Kansky 1981).

Instructional and Staffing Issues

Computer assisted instruction. In higher education, the computer provides instruction in the form of drill and practice, tutorials and individualized instruction, simulation, problem solving, and testing. Commonly known as CAI, this computer assisted instruction can be particularly useful in basic skills, computer science, mathematics, and computer literacy courses. Studies of CAI, however, indicate mixed results, often showing no consistent positive or negative effects on student achievement or attrition (McCullock 1980; Atchinson 1978). Many of the predictions for a rapid conversion to CAI did not come true in the '60s and '70s. Even the prestigious Carnegie Commission, writing on the "fourth revolution" in higher education (Carnegie Commission 1972), did not anticipate many of the problems.

The role of the computer in computer literacy, CAI, and in education in general, has centered on four main types of activities:

1. making computations that would otherwise be tedious and time-

consuming for administrators, faculty members, and students
2. organizing and presenting information
3. helping the instructor and the student of the computer to organize and develop ideas and activities
4. simulating and modeling real situations

In practice, these tasks are not necessarily independent of one another and generally use the computer's ability to interact with the learner. Although the first of these has been more prevalent in the past, the fourth is being used more today and holds the greatest potential for applications, particularly in business, sociology, and education (Zinn 1978, p. 85). The literature also demonstrates increasing research and applications in the areas of handicapped and special education (Thorkildsen and Williams 1980, pp. 36–38).

Although they are discussed throughout the world, computer assisted instruction and computer literacy appear to be most highly developed in the United States, the United Kingdom, Canada, and Japan (Chambers and Sprecher 1980, p. 334). John Hirschbuhl (1978) predicts that both Asia and Europe will solve soon their problems of outdated and incompatible equipment. Reports of Japan entering the world microcomputer market confirm that his prediction is coming true.

In principle, the advantages and disadvantages of CAI stem from the new solutions that the computer provides to old problems, rather than from any inherent merits or defects of the computer. "Perhaps the most widely accepted value of CAI," according to J.A. Chambers and J.W. Sprecher:

> *is that it involves the individual actively in the learning process.... Another much touted value is the ability of the learner to proceed at his own pace, which has strong implications for both the slow learner and the gifted person.... A final comment regarding the benefits of CAI relates to remedial education. The problems of handling remedial training for students have increased, because the problems of bilingual and disadvantaged students and the inadequate English and mathematics skills of entering university students are being recognized. Computer tutorials, especially in these areas, appear to be both educationally sound and reasonable in cost, if approached in an appropriate manner. Similar cases can be made for the use of CAI to support continuing education and in industrial training programs (Chambers and Sprecher 1980, p. 333).*

According to Chambers and Sprecher, the difficulties of implementing CAI can be categorized in order of importance as: (1) the need for faculty and training directors to move from familiar methods to new methods where their lack of expertise may arouse some fear and antipathy; (2) the confusing diversity of computing equipment, CAI materials, and CAI languages (the majority of CAI software is often poorly constructed, undocumented, and able to run only on the brand or model of computer for which it was designed); and (3) the cost of CAI hardware and software and the personnel and consultants needed to implement CAI.

Although job security has been cited as a concern (McCullock 1980; Wolitzer 1977), the major reasons for faculty resistance to using computers in the classroom, and becoming inherently computer literate, have been itemized by Peter A. Wolitzer (1977, p. 82) as:

1. the research orientation of faculty who believe that research is threatened by an emphasis on teaching
2. the need to learn a new discipline, not simp'; in a perfunctory way but at an indepth mastery level
3. the greater reluctance of today's union members to be as innovative as their nonunionized colleagues of the past
4. inherent conservatism of faculty who are not readily open to innovation and risks associated with computers
5. role overload of faculty members who believe that they have enough to do without having to spend additional time and effort learning new teaching techniques and learning processes.

In higher education today, the obstacles noted by Wolitzer have not been removed but each is slowly being overcome. Five major issues characterize the present situation in regard to CAI and computer literacy. Foremost among these is the development and sharing of quality software. There is an acute shortage of basic instructional software, but there is a surplus of business applications software. Most educational software available now is of a supplementary nature, often developed by faculty or small software firms for very specific purposes and usable only on one type of machine. Often this software is not well documented. Moreover, there exists little incentive for faculty to share software. During the 1980s, a few major software companies should be able to provide educational software that is of a more universal nature, thus partially alleviating the problem.

A second issue, that accounts in part for the preceding one, is that no standardized machine-independent language combines the features needed by computer literacy instructors or by those participating in CAI. This is one of the most serious impediments to the widespread use of computers in all the areas to which it can be applied, including computer literacy and CAI. Futhermore, software for translating from one language to another will probably not be available until late 1982 or 1983.

The expanding availability and use of microcomputers is helping to alleviate the third major issue—computing hardware. The availability of inexpensive microcomputers with multiple capabilities and appears to be the technological breakthrough needed to yield significant increases in CAI and computer literacy at all educational levels. James Eisele (1979) believes that a new era of educational application is at hand.

The fourth issue, that of implementing CAI and computer literacy courses and requirements, appears to stem from a lack of resource support such as background and backup materials and faculty or consultants who can provide immediate and repeated encouragement or aid. Clearly, the resolution of this issue is tied to those above.

Lastly, the effectiveness of CAI remains a major issue. One problem is that different investigators define effectiveness differently. Also, well-designed, tightly controlled evaluative studies of the use of CAI are rare (Chambers and Sprecher 1980, p. 335). Chambers' and Sprecher's 1980 review of the literature did reveal the following consistent conclusions, however:

- CAI either improved learning or showed no differences when compared to the traditional classroom approach.
- CAI improved student attitudes toward the use of computers in the learning situation.
- Faculty are more likely to accept and use CAI materials if these materials have been developed according to specific guidelines.

Similar conclusions were found by Beard et al. (1975) and Atchinson (1978).

Who provides computer literacy? Recent articles argue that computer science belongs among the liberal arts. But the concept of computer literacy spans the entire university cirriculum. Although some faculty and administrators maintain that computer science is not a part of the liberal arts tradition, nearly everyone agrees that computer literacy certainly is useful and desirable for the liberally educated individual. Yet not every course presently being offered in computer literacy and computer science is of the highest quality needed. A major reason for this is the unavailability of qualified instructors and a lack of faculty development funds.

The situation is no different at the secondary school level, where the staffing problems in science, mathematics, and computer science have reached near-crisis proportions and for similar reasons. Within this context of scarcity, computer literacy courses at both secondary and college levels are being taught by whichever department can acquire the instructors and the equipment. This means that computer literacy courses often are being taught by individuals whose only training in computer applictions has been on their own personal computer. In fact, computer literacy courses are staffed primarily by individuals with backgrounds in areas other than computer science, such as mathematics or business (Raltson 1981; Young 1980). Existing programs, it turns out, are slanted toward the particular field of interest of the instructor, to the exclusion of more general applications and concepts.

As faculty members attest, acquiring proficiency in the use of computers in the instructional process is an activity that requires concentrated time and effort. Awareness of or exposure to computers simply does not qualify an instructor to use computers in a classroom or laboratory setting. Few faculty members are sufficiently motivated, or have the time and energy, to prepare themselves for computer work while they are carrying a full-time teaching load. Teaching computer literacy thus falls to the few computer science faculty and others who may be qualified.

Computer literacy can be developed either through a survey course or by an integrative approach, depending partly on the background of individual faculty members. The prevailing consensus, however, is that the former, offering a survey course for general enrollment, is the best for students and is easiest to implement. In fact, such courses are common in many two-year and four-year colleges.

Computer literacy might also be provided through campus libraries. Although librarians are becoming regular users of computers and are well aware of CAI, the concept of housing computer literacy materials and CAI software as one would other library and audiovisual materials has not been developed. Computer literacy and CAI materials are viewed as far more dynamic than other library materials. Thus, although libraries in general may want to add CAI as a new tool, the interactive nature and the rate at which the field is changing presently precludes any major shifts away from the classroom and lab (Lyon 1975).

Staffing computer literacy courses. Those institutions offering a computer science or data processing major may be able to recruit faculty from these programs to teach computer literacy. Faculty in schools of education faced with retrenchment might be another source. Some computer center staff now teach these courses, but their backgrounds often are too narrow to be ideal. Institutions also are recruiting adjunct faculty from local businesses and industry. In fact, L.F. Young argues for "selecting MIS [management information science] teachers from among experienced and successful practitioners" (1980, p. 73). Given the experience and background of many of these adjuncts, they can usually become good instructors. Adjuncts, however, normally teach in late afternoon or evening, thus causing a shift in computer laboratory hours, timesharing allocation, and computer center capabilities for those institutions employing large numbers of adjuncts. The associated shifts in costs must also then be considered.

Instructors for computer literacy courses are drawn most often from computer science and business departments. This appears to be somewhat in line with a recommendation the Association for Computing Machinery made in 1979:

> *Faculty of computer science departments must be willing to offer different courses for those [nonmajor] students than for majors when it is appropriate.... Heads of departments must make difficult decisions regarding how much of the department's teaching resource is to be used for majors and how much is to be used for students in other disciplines (Austing et al. 1979, p. 162).*

For those institutions that are able to employ graduate assistants, the instruction usually will be near state-of-the-art and will carry the enthusiasm of the new convert. Former graduate students, particularly secondary school teachers, are another source of instructors. Some colleges and universities already are hiring secondary school teachers, many of whom have at least a master's degree and many years of experience teaching computer programming and data processing. This latter development suggests that hiring requirements may be relaxed for at least the next few years. The question then becomes one of doing the same for full-time positions. Following such a course will pose problems relating to tenure and promotion. Having standards for compensation or teaching loads differing among departments will tend to create even more problems (Ralston 1981, pp. 21–22).

Computer literacy and continuing education. Continuing education is a growing area, particularly as the need for computer literacy has developed in the business, industrial, and government sectors (Gilbert 1980). Many colleges and universities offer continuing education courses in computer science (interpreted in the broadest sense) along with their degree-oriented computer education curricula. Although some universities offer extension and short courses, the need for both continuing education and early education in this field still outpaces these efforts. Present adult and continuing education programs are providing professional development workshops and seminars, usually of the one- or two-day format, and evening, weekend, and off-campus adult education courses for general computer awareness and for the use of a home or personal computer. There are two very different aspects to these activities. Professionals who seek to enhance or update their expertise have different needs from persons in business who primarily want the most efficient use of their computer technology. Similarly, the continuing education needs of teachers, curriculum coordinators, and administrators differ from those of persons desiring to use their machine for home finances, record keeping, or stock market analysis.

The knowledge base in most areas of computers and related technologies is doubling approximately every five years, and adult and continuing education programs must continually guard against obsolescence. The increasing capability to deliver instruction to an individual's home, business, or work place should provide continuing education programs with new opportunities for service and expansion (*Educational Technology* 1979, p. 17).

Administrative Considerations

A number of studies in the field predict that the 1980s will see an increased use and production of data. Additional users and information will increase the demand for timeliness and accuracy. Administrative planning and computer use will have to be efficient and effective as institutions work to balance their support of the instructional, research, and administrative needs of the institution (Stamen 1979). This section reviews the trends and issues associated with computer literacy and its relationship to the areas of planning, central computing facilities, faculty and staff development, and institutional costs.

Planning, Facilities, and the Future

Planning considerations. The use of computers has been growing in management information systems (Vyssotsky 1981) and for education at the elementary through pre-college levels (von Klein 1979). Changes in pre-college education have occurred more quickly than at the collegiate level, and the impact of these changes is just beginning to be felt. Samuel Dunn predicted in 1978 that:

> *In the next twenty years,... there will be fundamental changes in higher education that* will *effect the delivery of instruction, and* will *effect what the typical professor does... The changes will be so significant that the very existence of higher education as we know it today will be threatened. Many institutions won't be able to survive the transition. By the year 2000, twenty-five percent of the currently existing residential liberal arts colleges will be gone. Many other colleges will find their existence threatened and will be searching hard for ways to survive. (Dunn 1978, p. 2).*

More recently, Robert Gillespie noted that:

> *The extent to which technological changes will affect the structure and organization of the university—the impact on faculty, administration, and budgeting—is unknown. Changing patterns of resource allocation and the increased use of microcomputers for research and faculty support need to be considered (Gillespie 1981, p. 174).*

With the changes in the structure of higher education comes the growing national concern over the capacity of our educational system, at all levels, to provide technical and scientific training and literacy and education for all students, including those who do not intend to pursue technological or scientific careers.

Nationwide, colleges and universities are continuing to integrate computers into recruitment and retention efforts, financal aid packaging, guidance and monitoring, and registration. Administrative offices, in particular, have increased their use of computers as more efficient and comprehensive computer software packages have become available. Overall, it is evident that administrators must know what computer literacy and computer use mean to the institution—what the impact is, both pro and con. As institutions adopt comprehensive systems that gather and provide biographic, demographic, academic, and financial data on every student in the institution, the need for planning and development increases, (McLaughlin, Montgomery, and Mahan 1978; Bess 1979).

Although the needs and problems are not the same for all institutions, the issues that usually concern administrative computing are administrative and academic access, software problems, enrollment surges, and planning and forecasting problems. Moreover, administrators' ability to use information usually is not uniform across a particular campus. Technical problems are not as pervasive as human ones—overcoming inertia and fear and setting and supporting priorities. Similarly, the access issue is becoming twofold as more students and faculty demand access, both to facilities and to information. The facility access problem presently is being exacerbated by the increasing number of students and faculty who are bringing personal computers to the campus and connecting them to the campus computing facilities. The resource demand for time, information, and software can only increase.

The information access problem is both a policy and a political issue. In Minnesota, for example, state-level policies, decision making, and support are deemed necessary for equal access by students and faculty to both computers and the information they control (Klassen et al. 1980). This kind of state-level activity, in turn, calls for a commitment on the part of both the higher education establishment and state legislature. If this commitment does not exist, computer enrollment and staffing problems already encountered in many universities will spread (Schultz, March 1981, p. 9).

Due to the lack of appropriate software, many administrative and planning decisions have been based on available hardware. With the institutional problem of hardware acquisition has come a related problem that also is complicating planning decisions: lack of overall coordination among offices and departments as they separately acquire low-cost microcomputers and related hardware and software. The results have been incompatibility and an inability of the institution to plan further acquisitions based on past use. This lack of information use makes forecasting future use difficult (*Educational Technology* 1979, p. 28). Moreover, with the increasing campus use of microcomputers and networks of microcomputers dedicated to single tasks, the planning and decision-making process can no longer rely solely on the institution's computing center. Many changes and new combinations of resources are becoming apparent as higher education further adjusts to the impact of computer literacy and computers.

The impact of computer literacy on facilities. What were once single-unit punched card operations are now major computer centers offering a multitude of services, computers, and facilities. Colleges and universities are shifting from punched cards and remote terminals to more sophisticated applications (Wetherbe and Dock 1978). This is attributable primarily to the introduction of the microcomputer into educational activities. Users with their own computers ostensibly have little reason to use the services of remote terminals or the campus center for routine computing. Some institutions regard the growing use of microcomputers as destroying or at least running counter to the network or computer center efforts of the institution. This is only partly true since the spread and use of microcomputers also has caused a mutual and complementary reinforcement of services Many who start out on a microcomputer eventually end up on a larger system as they encounter more complex research applications or massive data handling problems. And others who previously tied up a larger system with smaller or more immediate problems are now using microcomputers instead (Zinn 1978). The net result is that the two systems essentially work together to reduce the dependency of users on the local center or the area network. Users now have more options in terms of applications, machines, availability, and access. With the independence and increased number of options, however, comes an increased responsibility on the part of the user to plan, develop, and implement the most efficient use possible.

The effect on computer centers and networks has been predictable. Some campuses have closed down their central computer operations and instead are using campus-based networks composed of clusters of microcomputers. These trends do not necessarily mean the end of local centers. Rather, those institutions retaining a computer center are seeing the function and autonomy of the center shift more toward the user. As computer literacy continues to spread, computer centers are evolving more towards general assistance and consulting.

The costs of computing also are dropping, not only because of the lesser costs associated with microcomputers, but because of the cost per configuration. That is, a typical time-shared system costs approximately $100,000 for the central processing unit and about $1,000 for each user terminal By comparison, a microcomputer cluster costs about $2,500 per user terminal after an initial outlay of approximately $20,000 for the central or coordinating microcomputer. Thus, it costs nearly $120,000 for 20 users on a time-shared system, the cost for 20 users on the microcomputer system is about $70,000. Another consideration is when the central system is down, the entire network is down, if the central microcomputer fails, the individual microcomputers can disengage from the central one and run independently (Schultz 1981a, p. 12).

With the recent entrance of many of Japan's high-technology firms into the microcomputer market, increasing competitiveness and new technological developments should directly affect the costs of computer hardware, software, and instruction. Predictions for the year 1990 include computers that will cost about one-tenth of those today, with the performance/cost ratio increased by a factor of four (Dunn 1978, p. 5). The mid- and late 1980s thus should be a time of evolution, opportunity, and expansion for those seeking to become computer literate.

The future. Recent changes in computer and telecommunication technology are having far-reaching effects on the delivery, management, and cost of computer education. With the convergence of communication technologies, videodiscs (Bork 1976 and 1978) and computers have come new educational needs as well as new opportunities for attacking present problems. Combinations of these technologies and associated software are motivating new approaches to subject-matter organization and teaching strategies. These technologies are resulting in stronger interrelationships among different fields of study, a better connection of science and mathematics curricula with the future needs of students, and inexpensive and more individualized diagnostic and performance testing that is more sophisticated than current multiple-choice techniques (National Science Foundation 1980, pp. 5–6). Moreover, the merger of these technologies has presented new possibilities for delivery of college and university curricula directly into the home or office (Bork 1978). With the decreasing price of videodiscs and the increasing spread of cable television, more opportunities and applications are occurring. Some authors predict that by the year 2000, 80 to 90 percent of the homes in the United States will be connected to a video cable (Dunn 1978, p. 10). The next step is to combine the use of home microcomputers and cable systems.

Similarly, touch-tone technology has created the possibility of using telephones as data entry terminals. Although banks and similar institutions are the present users, financial aid offices, student and faculty credit unions, student center banks, and bursars' offices are expected to adopt these techniques. Telephones that accept data are being used together with key devices that contain memory units and a video display.

Typewriters are changing from electric to electronic and are acquiring the characteristics of computer terminals. New designs allow for the addition of storage systems, communications facilities, and video display and are linked to high-speed printers.

Campus offices and computer centers should feel the effects of the new technologies by the mid-1980s, if not sooner, if qualified staff are available. However, these new technologies may increase clerical labor costs by 4 to 10 percent (Makower 1980, p. 136).

As society and higher education demand faster and more efficient computing power, computer research continues in both industry and university laboratories. The computer architecture of the 1980s is expected to be more diversified into what are now called distributed systems. Already, universities and businesses are shifting from the single processor system of the 1970s to an interlinked architecture of fourth-generation microcomputers (Stone 1980, pp. 21–24). Many software firms and publishers see 1981 as one of the best years to date for the development and distribution of software. Major venture-capital funding is predicted to merge, peaking in late 1981, in support of independent software development. Given this, educational and administrative software will continue to be developed as computer literacy and computer usage increase.

The Cost of Computer Literacy

One of the greatest planning concerns is that of cost. Even though the cost of computing hardware (memory, in particular) has decreased over the last five years, there has been increased cost for personnel, curricular consultants, literacy software, and support facilities (McLaughlin, Montgomery, and Mahan 1978, p. 4).

> *Cost pressures have caused many decision makers to evaluate their current computer resources and to carefully plan any further development or expansion of existing equipment. Such planning depends heavily on an accurate assessment of computer needs. The traditional forecasting techniques which use some form of trend analysis are of limited value when determining future computer needs. After all, prior use may be a function of equipment available rather than an indicator of the actual needs of users.... An even more serious problem is the difficulty presented by mutually exclusive knowledge. Experts in computer technology, for example, have little insight into the future computer needs in other curricula. Advisors may not know the specific details of computer use in courses taken by their majors in other departments. Faculty teaching courses which use the computer as a tool do not know of trends in other courses which their students take. A final problem is that internal cost procedures for computer use may be established to modify behavior (for example, use disks, not cards) rather than to reflect the costs for various uses. (McLaughlin, Montgomery, and Mahan 1978, p. 4).*

It is evident that a necessary institutional cost is that of providing computer access and services in support of computer literacy and, by implication, of more sophisticated computer applications at all levels of the institution. If access is to be through centralized time sharing, then the cost of terminals and telecommunications is significant. With the expected tripling of the cost of telephone communication for computer and data processing applications, a few universities are confronting the possibility of installing their own telecommunications system (Vensel et al. 1981; von Klein et al. 1979).

The costs for educational computer usage are normally "hard" money as compared to the "soft" money provided by most research grants for computer usage. This is particularly the case in starting a new program in computer science or computer literacy. Given the fact that nearly every institution of higher education has a computing facility, or at least access to a computer network, the only additional start up costs are those for microcomputers and associated software. Assuming one such unit for every 20-30 nonmajors and a cost of $750 to $2,000 per unit, the cost of equipment, when spread over a number of years, is reasonable. Computer facilities for a computer science program cost more.

The issues of reducing costs and improving services remain. Although computer services have improved, cost savings have occurred in only a few areas. For example, instructional costs remain high, but the costs for clerical and administrative services have decreased as institutions adopt word processing (Stepien et al. 1980, p. 402). Since word processing maximizes administrative support services and planning with minimal staff training and initial outlay, more institutions are turning to it to achieve an efficient and productive level of operation. Word processing is a natural match for educational and clerical applications, and the 1980s will see the convergence of the administrative office and data processing (Stepien et al. 1980).

Recent advances promise to expand word processing and text editing to all segments of the campus. New programs find spelling and typographical errors, proofread 10,000 words per minute relative to a 20,000-word dictionary stored in the computer's memory, and store and retrieve materials faster, cheaper, and more efficiently than earlier programs. Similarly, there can be significant savings in the overall operation: replacing paper and print time with microforms or on-line facilities; reducing file folders, file cabinets, and office and storage space; replacing key-data operators with point-of-origin data entry (Aherne and Navarro 1976; Magarrell 1980b).

Another problem area in cost savings has been the decision to buy or rent equipment. With the increased availability and reduced costs of microcomputer systems, the decision increasingly is to buy. A growing number of institutions are decreasing their network and time-sharing usage by relying more on mini- and microcomputer systems. But there is still a problem relative to federally funded computer usage. Many National Science Foundation grants, for example, provide for computer equipment rental, but not purchase (National Science Foundation 1980, p. 5). Thus, in a grant totaling $30,000, as much as $3,000 may be spent for rental, but not one dollar may be spent for the purchase of equipment.

Computing costs are not only incurred by equipment and software purchases. Inefficiency and mismanagement cost an institution more than just financial resources. Because a sophisticated level of planning and management is needed for the effective and efficient use of an institution's computer resources, many institutions have elected to use the services of educational computing firms. As the American Association of Community and Junior Colleges and the Association of Community College Trustees have reported: "A number of our member institutions have gone beyond their internal computer staff to seek special, professional management expertise.... These institutions have elected to hire outside computing resource management firms specializing in educational computing" (AACJC/ACCT 1980, pp. 12–13). In time, however, escalating salary, supply, and maintenance costs cause some institutions to take back the operation.

The costs associated with computer literacy are complex, involving direct and indirect aspects, capitalization and investment problems, and long- and short-range budget planning. Nationally, the evidence is clear that practically every institution has recognized the issues, but not all have been creative enough to begin resolving them. "For a computing effort to be responsible and remain politically viable, balancing the pressing and often conflicting computing requirements of instruction, research, and administration is essential" (Wetherbe and Dock 1978, p. 1015).

Faculty and Staff Issues

All across the country, faculty members are auditing computer courses.

They are learning how to use a microcomputer or a new computer language, brushing up on an old language or learning new applications, or learning the latest in word processing. Even those considered computer literate or fluent are seeking to upgrade their skills and knowledge. It has been estimated that the knowledge turnover in computer science and data processing is four years. On this basis, *Computing Newsletter* (1981, p. 8) recommends that faculty and staff should spend 25 percent of their time acquainting themselves with new developments. Similarly, faculty teaching computer literacy and computer science classes must stay ahead of their classes. Since faculty members need more information and experience than students or staff, faculty development should take priority over upgrading staff analysts and programmers. Some authorities claim that a third of a faculty member's time should be spent in development as compared to a quarter of a staff or analyst's time (*Computing Newsletter* 1981, p. 8). Highly motivated faculty and staff will work on self-development and study materials, but their institutions must provide equipment and time. Moreover, meeting and interacting with other experts are of fundamental importance in the more complex and theoretical areas. Additional support may be needed for seminars, workshops, short courses, and conferences.

Many faculty, staff, and administrators view computers with fear or anxiety and often with outright hostility. They fear that "computers will eventually replace us." This fear is, for the most part, ungrounded because computers free people from the more mundane and repetitive tasks and leave them time and energy to create solutions to more subjective or esthetic kinds of problems. Computers will not justify a reduction in faculty, because they cannot substitute for the human interaction and support required and demanded by students. The case for clerical staff, however, is not as clear, as Adam Osborne (1981) has noted:

> *We must now question the economics of such fundamental and hallowed traditions as having secretaries type letters for bosses, or clerical workers prepare financial data for managers. In the future, neither efficiency nor economics will justify such procedures. In most cases, only expensive, intangible considerations such as prestige and tradition will allow these inefficiencies to persist. Even the concept of an office, where people gather daily and work together, will need to be questioned.*

The integration of word processing into an office or typing pool can allow a reduction in staff or provide the institution new flexibilities in staff assignment. The implications for staff and clerical help in financial aid, housing, registrar, admissions, advising, and guidance offices is clear: The computer saves time, effort, and money. But staff members have to be able to use it, and so they too, are seeking to become computer literate.

Demand for computer literate employees is growing. John Foreman (1981) of Texas Instruments, predicts that only 25 percent of available bachelor of science positions for computer scientists could be filled, a shortage of over 40,500. Such figures are repeated by the Association for

Computing Machinery (Conte and Taulbee 1980) and other authorities, such as John Hamblen (1979). Similarly, there is a growing need for computer literate clerical staff. Although no national figures seem to be available business and vocational programs at the secondary and community college levels are continuing to integrate computers into their programs. In addition, more and more faculty members, in departments ranging from art through zoology, are demanding information and training on microprocessors and training in word processing, statistical appalications—particularly since the introduction of the Statistical Package for the Social Sciences (SPSS)—and in BASIC for their home computer and in COBOL* for the "consultancies."

At the same time faculty with some computer training are abandoning higher education (Magarrell 1981b, p. 3), and secondary education for that matter, to take more lucrative and more promising positions in business and industry (Schultz 1981b, p. 9). And the situation is not going to get better; salaries and research facilities are so attractive outside academe that few students see any need to study for a Ph.D. Similarly, the industry's demand for bachelor's and master's degree-level computer scientists is not expected to level off for many years. In many colleges and universities, as much as one-third of the staff are part-time or temporary. Moreover, because the bulk of the retirements in certain liberal arts disciplines and in teacher education may be up to ten years away, the upper ranks will remain full and opportunities for promotion will be slim for those faculty remaining. This makes it even more difficult to hire computer-oriented faculty. Nationally, the situation is expected to worsen well into the late 1980s. (Hamblen 1979). Administrators who insist on filling a computer related position with black or female candidates may find that the position will remain open (Conte and Taulbee 1976, p. 313).

As administrators become users of word processing, it is important that they know exactly what they want in computer services and be able to communicate that need; they must at least have a rudimentary knowledge of what a computer can and cannot provide. The administrators who are responsible for the quality, content, and timeliness of reports, memos, and correspondence are the real users of word processing, not the salesman nor the typist following orders. Deans, supervisors, and managers know what kinds of documents need to be prepared, to whom they should be sent, for what reason and with what urgency, these administrators are the ones to decide what compromises are appropriate in appearance, speed, complexity, and cost (Vyssotsky 1981).

Developing Computer Literacy

Institutions have begun to recognize that the economic and institutional benefits reaped from research, instruction, development, management, information processing, and office procedures are dramatically increased

*COBOL is a Common Business-Oriented Language used by a majority of businesses in the United States.

through the use of computers, computer software, and computer literate faculty and staff. If, as predicted, computer terminals become as pervasive as telephones and televisions, much paper-based communication will soon be eliminated. Presidents, deans, and faculty alike are now able, at a few institutions, to write, edit, store, retrieve, transmit, and print a variety of letters, memos, reports, and similar documents using computer and word processors next to their desks. In fact, getting people to send messages by computer remains an effective way to start them on their way to computer literacy.

The need for programs developing computer literacy has increased for practically all members of the academy. To meet this need and those discussed above, there are several approaches:

> *The evolutionist would argue that the best way to internalize an innovation is to permit those who are motivated to use the innovation in their own way. . . . The revolutionary approach would seek to retool disciplines based upon the availability of the computer (Molnar 1973, p. 16).*

At many institutions, both approaches are being used to develop and educate faculty, administrators, and staff. The challenge is to make computers an enhancement to teaching and administration, not a substitute or distraction.

As the demand for user service continues to exceed supply, institutions are hiring outside firms that specialize in faculty and staff computer workshops. However, providing programs for development is one thing, ensuring quality is another. Institutions are learning that much more time and effort is required to become self-sufficient with computers than to become dependent on them or on a consultant.

In developing faculty and staff computer awareness, some institutions begin with a series of short inhouse workshops. Awarding some kind of credit, certificate, or continuing education unit is sometimes used as a motivational device. Generally, the workshops are designed to increase computer awareness, to explore the capabilities of computers, and to enhance users' skills. Typically, there are talks, demonstrations, and hands-on experience. Thereafter, alternate paths are used to accommodate different levels of need or kinds of applications. Some staff and faculty members are awarded development leaves or sabbaticals for updating or advancing their computer skills. There is a risk, presently, that upon completion of the leave, or as soon as possible thereafter, the individual will opt for advancement outside academe.

"Bootstrapping" appears to be prevalent. In this concept, staff from computer centers and faculty members aid other staff and administrators in becoming computer literate, and they in turn, help others. It is not unreasonable to estimate that the bulk of computer knowledge and applications is being spread this way. However, this method does not appear to work as well as a thoroughly planned and implemented developmental program of computer literacy (Carlson 1980).

Because of the rate of change in the development of computer technology and software, obsolescence is a recurring problem. Thus, the "computer newsletter" has been added to all the other newsletters and updates circulated on campus. The word-of-mouth approach is no longer viable for staying informed. What is needed is accurate and up-to-date information on new applications, software, and equipment, as well as timely announcements on new workshops or short courses.

National Issues

Although all the issues covered thus far are national in importance, we will now discuss those issues that especially require national strategies and approaches. The studies and review extend beyond a single institution and into the areas of national policy and cooperation.

Privacy and Security

With the growth of computer literacy and use has developed concern for the privacy of faculty and student data. This concern has increased at the state and federal levels as well. There is an increasing need to provide not only more information, but better security, more completeness and accuracy, and greater flexibility. Management and administration are directly affected since they are responsible, often in a legal sense, for the policies and procedures regulating input, access, and challenges and corrections (Hoffman 1980; Wessel 1974).

A greater problem is fear—fear that personal data are not safe or that they may be used in a detrimental manner. Students have been breaking computer codes and carrying on disruptive and illegal activities *(Chronicle of Higher Education* 1981a and 1981b). As more faculty, students, and staff become literate in the use of computers, and data banks in particular, there is an increased risk that personal privacy may be violated. The problem is compounded by the fact that without a great deal of sophistication or advanced training, computer data thieves are able to understand, generate, and change computer access codes. This is possible partly because of the increased speed and size of the newer computing systems. As these systems increase in speed and efficiency, programs can be designed to try literally every possible code combination.

Parents and students alike are becoming more conscious of their rights: notification, access, challenge, prompt correction, erasure, redress, and control. With these rights, neither students nor parents will accept future information systems that do not show serious concern for personal privacy and have adequate safeguards against intrusion into personal and sensitive data (Hussain 1978). In 1974, Milton Wessel provided minimum standards for any data bank of magnitude (Wessel 1974, p. 45). These standards apply to present data banks, in general, and have particular implication for tenure, recontracting, merit, and promotion files. Minimum standards are:

- public notice of the existence, extent, and nature of data banks
- clear assignment of responsibility for administration and security to designated identified persons
- right of access in appropriate circumstances
- correction and deletion of outdated or inaccurate materials
- assurances of security to avoid error and misuse
- maintenance of adequate records of entry, access, use, and deletion.

A second area of concern is the theft of the computers themselves. With the advantages of miniaturization has come the disadvantage of being highly portable and thus easy to steal. Because many internal parts are often dated, but not serialized, tracing or recovery is virtually impossible. Better locks, bolted-down equipment, and security checks are becoming necessary, which further increase costs.

A third issue is that of securing software and information against theft. The debate over what legal protection may be afforded began in the mid-'60s and is nowhere near ending. Daily, the size and uses of data banks continue to increase. The central issues revolve around whether computer programs and software can be copyrighted, patented, or protected in some way. In December 1980, Congress amended the United States Copyright Law to permit computer programs to be copyrighted ("Copyright Law Amended" 1981, p. 1). But, with a million new programs a year, the U.S. Patent Office often is not able to decide whether a particular program is unique enough to be patented. Thus, how a computer program is defined or characterized becomes important to researchers, authors, attorneys, administrative offices, legislatures, and courts.

The point is, however, we do not know what a computer program is (Gemignani 1981). We do not know whether it is a paper listing, a punched tape, an algorithm or process, a fixed pattern of switches and circuits, a set of electromagnetic patterns, or all of the above. And, just as there are many ways to define a computer program, what a program accomplishes can often be written in many ways and in many computer languages. Even two programs written in the same language and using similar algorithms can look entirely different. Determining what constitutes copying or stealing software or a program is difficult.

Computers also are being used to create new and exciting forms of music, art, and poetry. Should these computer-produced creations be accorded the same rights and protections as those produced by humans? Dictionaries, encyclopedias, reports, and literary works can all be stored in a computer's memory bank, and any part can be scanned, rewritten, duplicated, or transmitted electronically. Ownership effectively becomes a matter of access. Publishing and distribution becomes a matter of satellite communications and computer typesetting (Ryland 1979).

Whether computer art and music are, in fact, the creation of a byproduct of the artist's program is the underlying issue. The courts eventually will have to decide the relationship between patentable programs and the copyright status of what they produce. Until then, the opportunities for infringement and copying continue to increase, and we must work to increase public awareness that computer-produced art, music, and literature should enjoy the same protection as any other form of artistic endeavor (Wessel 1974).

Networks

Over the past years, the National Science Foundation has supported the development of about 30 regional networks among colleges and universities. Many states have developed statewide networks, of which the Minnesota Educational Computing Consortium (MECC) is a typical and successful example (Rawitsch 1981, p. 453). Generally, networks provide those institutions with minimal computing facilities the opportunity to use larger and more powerful systems (Educom, August 1980). They also serve the consulting and software needs of faculty and staff. Presently, though, a growing number of schools are increasing their reliance on their own campus-based networks. In fact, according to some authorities, the past experiments in broader networking and resource sharing, although working, have had limited or no impact either from a financial or educational viewpoint (Gillespie 1981, p. 8).

Recent efforts that use national data bases and advanced specialized software may finally begin to achieve the objective of networking. Nationally based networking efforts, such as CONDUIT, (Computers at Oregon State, North Carolina Educational Computer Consortium, Dartmouth University, University of Iowa, and University of Texas at Austin), EDUNET (Educational Network), OCLC (Online Computer Library Center), and others, have made network participation much more feasible and available than in past years. Typical of these is the EDUNET network (Educom, August 1980). As a membership organization of colleges, universities, and other nonprofit organizations, EDUNET provides its members with access to more than a dozen computers on campuses other than those of the participating institution. EDUNET does not own or operate a computer, but arranges for the supply of computer resources and services. Often, foreign and domestic users share the same resources.

It is likely that these network applications will continue to proliferate (Hiltz and Turoff 1978). The following sampling of applications represents only a fraction of potential network opportunities and clearly shows the impact computer literacy and networking are having on one another and on higher education in general:

- *Social scientists in Hawaii, Oregon, and France participated in a seminar using a teleconferencing system in New Jersey.*
- *Two schools of library science and education in North Carolina are using WISE at Wisconsin to train students in bibliographic search and retrieval techniques....*
- *Administrators at more than 80 colleges and universities continue to use EFPM [Educom Financial Planning Model], a financial planning and modeling system at Cornell.*
- *Law school faculty on two different campuses rely on EDUNET to develop jointly an expanding set of CAI programs at the University of Minnesota. Classes at more than 20 law schools are using these same programs in tort law, civil procedure, and other topics....*
- *A small college in Delaware, offering a computer science curriculum for the first time, is using EDUNET exclusively until its own computer is installed....*
- *An environmental research team at Cornell is using the MPSX-MIP [Mathematical Programming System eXtended-Mixed Integer Programming] package at Rice to solve a large mixed integer programming problem involving water quality management....*
- *An educator in Appalachia used programs at Minnesota to train his*

students in diagnosing adult illiteracy problems.
- *A political science professor involved her students at the University of Delaware in METRO-APEX, the urban simulation game at Cornell.*
- *To introduce CAI concepts in a computer literacy workshop for faculty, a small Ohio college used programs at Minnesota and Notre Dame (Educom, fall 1980, p. 8).*

When administrators, faculty, and students become computer literate, they usually demand more services such as those described above. Moreover, as the cost of research and doctoral programs increases, it makes economic sense to share not only data, software, and equipment, but faculty resources as well (*Chronicle of Higher Education* 1980a, p. 2). This is particularly true in such areas as computer science, medicine, and engineering. Through a network, faculty and students are able to cooperate on research projects and collaborate with an increased number of other students or researchers. At the same time, the costs for such an arrangement should be no more than that estimated for separate programs on each campus cooperating in the network.

In 1974, as networks were appearing as an alternative to the computing deficiencies of many campuses, some problems and conclusions were described by Martin Greenberger that still apply today and that have particular application for those campuses developing their own local networks (1974, pp. 22–23):

> *The major problems to be overcome in applying networks to research and education are political, organizational, and economic in nature rather than technological. . . . Networking does not in and of itself offer a solution to current deficiences. What it does offer is a promising vehicle with which to bring about important changes in user practices, institutional procedures, and government policy that can lead to effective solutions.*

The major goal in using a network strategy still is to meet the needs of the users rather than to contrive new uses for new technologies. The need for good, comprehensible documentation and user assistance remains a high priority, regardless of how advanced or accessible the equipment is. Similarly, the issues surrounding data bases, particularly those of national size and import, remain as the access and the use of computers become more extensive.

National Data Bases

The establishment and use of national computer data banks pose a number of problems and issues. Generally, research depends on sharing new information. But many in higher education and the federal government believe that there is a growing danger in the concentration of information about people and their research and the increasing possibility of access to repositories (Wessel 1974; "Computer Privacy" 1977; Hoffman 1980). Beginning about 10 years ago, computer security became a risk industry

(McGowan 1981). Since then, with the number of users and faster computers continuing to increase, computer theft, in particular, has continued to spread. Computer abuse falls into three categories: theft of computer time; manipulation or destruction of information or data; and theft or unauthorized use of data, information, or programs. "Especially hair-raising is the fact that computer abuse can take place from thousands of miles away; there may be nothing to stop someone at a terminal in Paris from stealing information or money from a data bank in Phoenix" (McGowan 1981, p. 1).

Although colleges, universities, businesses, and governments may want to use and control data banks, it is ultimately up to the public to decide how much freedom it is willing to give up to achieve the benefits provided through the use of data banks. As may be seen in practice, control of the data bases masks the more crucial issue of the threat to personal freedom implied by the very existence of the data bank (Wessel 1974, p. 37). As noted in an earlier section, students at all educational levels are discovering ways to change grades, records, or research data by invading data bases. Tampering of this sort is occurring nationwide and can be expected to increase. Similarly, access to classified research, medical information, biological and drug research, and financial records also occurs. When networks and data banks are international in content and access, in fact, satellite and telecommunication systems only make access easier and more anonymous, thus increasing the probability of theft. On an international scale, each faculty member, administrator, and student who pursues the structure and mechanics of data bases must be aware of the potential danger of their knowledge and assume the personal responsibility for it. The need for an appreciation of the societal impact of computers grows with the level of computer literacy and use.

The Federal Role in Computer Literacy

The continued productivity, world leadership, and national security of the United States have been irreversibly linked to computer technology and its many uses. Similarly, other of the world's economies also are becoming based on the production and distribution of information. Yet there are presently no national goals or policies regarding computer literacy in the general population. Technology is developing so rapidly that neither state nor federal agencies are able to keep up with either support or oversight. The areas of national and international networks, data banks, computer-media communications, and instruction as a home-based concept have not been addressed on a national level.

The federal government also has its own internal problems.

> *Computers in the federal inventory are out of date, with only two percent of the large and medium-scale computers using 1975 or later technology .... Agencies have not recognized the costs and problems of continuing to use outmoded equipment.... The current murky acquisition cycle, which is long, complicated and frustrating, has contributed to the obsolescence of Federal computers (Comptroller General 1980).*

State agencies and institutions have encountered similar replacement and updating problems. Although financial resources are a part of the problem, efficient and effective management of present computer resouces is clearly at the heart of the situation.

National security problems often turn up on campus in connection with government-supported research. Although most problems of the past have been effectively resolved, debate continues over the government restrictions on computer-code research. Access to government and military data banks and the transmittal of classified information increasingly rely on the use of computer codes, ideally unbreakable. The problem actually revolves around whether a given computer code is considered to be secret or nonsecret. Additionally, the National Security Administration (NSA) becomes involved at this point since it is responsible for secret military and diplomatic codes. To help solve the problem, the American Council on Education (ACE) formed the Public Cryptography Study Group, which recently recommended a system of voluntary censorship (Magarrell 1981c, p. 10). This recommendation is in opposition to the NSA's position that a law was needed to block the publication of cryptographic research that may be considered a threat to national security. The ACE's system asks that cryptographic research papers be submitted to the NSA for review before being submitted for publication. What congressional legislative committees will do with such proposals remains to be seen. In the meantime, research professors are participating in NSA-supported grants for nonsecret cryptography research.

Many authors believe that progress in the federal policy area will not be possible until the government agencies that support, affect, or regulate computer research and education work together to develop consistent policies, decisions, and actions. To maintain world leadership in computer technology, the United States must make a national effort to coordinate the production and processing of information, educational computing, and computer applications. Evidently, there will continue to be policy research by state governments, education agencies, and professional associations. As with similar situations in our nation's past, there are those in higher education who advocate that support should come from practically everywhere—start-up monies from state and federal funds, further support from the private sector, and leadership from professional organizations, foundations, and certain universities. However, given the present funding and support posture of the federal government and the current state of the economy, fiscal support is falling increasingly to the states, with the educational leadership coming from competing institutions. The resulting need is for ways in which state and national policy can work together more effectively to provide better coordination, leadership, and support at the national and state levels (Panel on Computing and Higher Education 1981).

Summary and Conclusions

With all that has been researched and written, clearly no one yet knows the intellectual or cultural impact of computers. If computers, microcomputers in particular, are comparable to the Model T Ford, then neither higher education, government, nor business really knows what the 1990s holds for us. A few conclusions are near certainties, however. As society becomes more of an information society, effective participation will require computer literacy. Although computer literacy is viewed by many to be as important as reading or writing literacy, as yet there is not enough evidence to indicate that this will be true for the general population. However, it will be most true for the products and consumers of higher education, namely, students.

Computers are not a panacea, but they have been shown to be one of the most responsive and potentially powerful tools that our society has ever developed. Perhaps no other tool or machine in history needs to be understood more, particularly by those of us involved in higher education. The more deeply higher education moves into computer usage and development, the more often arise questions of ethics, costs, and duplicating human accomplishments. Society's relationship to computers is mirrored in higher education's growing dependency on them. As many authorities have noted, when computers reflect, approximate, and surpass the minds of the scholars using them, fundamental problems of new proportions are raised. Whatever computer users need in terms of size, speed, quality, and level of sophistication is being planned and developed. The 1980s and 1990s represent a spectrum of choices for individual users and institutions alike. Individuals who are computer literate and institutions that have made a commitment to computer literacy and computer science education will remain in the forefront of progress in the 1980s and beyond (Aiken 1980).

Those institutions that have not yet entered the computer age, except in some token way, already may have been left far behind. For them, computer literacy implies a crisis of existence (Zinn 1978, p. 87). Elementary, middle, and high schools nationwide are accomplishing more with computer education than many state and small colleges. With such experience, students will find little reason to continue their education at a less than technologically modern institution, and their parents will agree. As the computer literacy movement burgeons in pre-college education, institutions of higher education have no choice but to accommodate the new talents and ambitions of their students. Computer literacy is entering higher education in an evolutionary sense as a part of the student's background. Although many authors and articles allude to a "computer revolution," the situation is one of continuing evolution (see, for example, Carl Hammer's remarks in Johnson 1981, p. 8). Thousands of entering students have used computers throughout their educational careers, and college is not the time for them to stop.

The use of computers in education amounts to thinking about education—its processes, outcomes, and support (Barstow 1979, p. 116). To dwell on the technical aspects of computers misses the intellectual potential that is inherent in computer-based instruction. It is clear that computer awareness is not yet being required of all college graduates. Moreover, for students desiring and needing computer literacy and fluency, there is a national need for a comprehensive curriculum that spans the elementary through college levels. Even though computer science is still evolving, definite curricular patterns, languages, social effects, applications, and skills have become evident. The merger of cable television, videodiscs, home computers, and campus-originated instruction and simulation barely has begun to develop. The potential for change in curricular development and instruction is enormous.

As microcomputers continue to decrease computer costs and increase portability, new off-campus delivery systems should emerge, providing different kinds of curricular and instructional opportunities. Computer assisted instruction may survive, principally because of microcomputers. Overall, however, CAI will remain an enhancement of regular instruction. With much of computer literacy being accomplished before college, many higher education institutions are not expected to make major investments in computer literacy or CAI. For them, computer literacy may well be relegated to the status of a basic skill and remedial programs established as needed, as Hamblen, has noted (1978, p. 3). Much of the impact of computer usage and literacy should appear later through the forum of adult and continuing education.

As long as state boards, trustees, faculty, and administrators disregard the potential of computers, their institutions will slip farther behind their counterparts in industry, education, and government. Similarly, as the "publish or perish" syndrome continues to combine with the attraction of nonacademic employment, even those schools with a head start on computer education and computer literacy will be affected by staffing and development problems. Innovation and flexibility are needed in the policies that govern hiring, development, promotion, and support of faculty and staff members.

Nationally and internationally, industry and business will continue to move ahead of higher education in the use and development of computers and in computer literacy. Although a few companies are forming cooperative ventures with higher education, they primarily are for research and development, not for the advancement of computer education (Leepson 1981, p 120). Thus, if educational applications and instructional research are to be developed more rapidly and on a national basis, institutional policies will have to be developed that allow for the support of instructional research and development that is comparable to the support given pure research. Since university computing tends to consist of self-interested entrepreneurial centers with little incentive to cooperate or give up any of their autonomy, national cooperation will not develop much further than it has already without some impetus. Evidently, the federal government is not yet committed to supporting computer education at any educational level. The task of intervention and motivation falls increasingly to national commissions, higher education associations, and professional groups. These groups must formulate national goals, support legislative development, and encourage national and interinstitutional cooperation.

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