The AIR Professional File Summer/Fall 1981
The Association for Institutional Research No. 10

COMPUTING AND OFFICE AUTOMATION—CHANGING VARIABLES

E. Michael Staman
Director of Computing Activities
University of Missouri—Columbia

Trends in computing and office automation—and ways in which these technologies might be incorporated into administrative activities—is a topic of present interest in higher education. Individuals responsible for planning, institutional research, and general administrative support (the "assistant to" officers who support deans, directors, presidents, and vice presidents) are particularly interested.

This article reviews some of the events which are causing significant changes in our understanding about how technologically based information-processing services will be provided and who will provide them. After a brief introduction, factors such as computing literacy, office automation, the availability of trained personnel, service models, and technological change are considered and are followed by some comments on implications for institutional research and a concluding summary.

Background

By now, most have seen the figures. The 1963 computer that cost one hundred thousand dollars, required one-half ton of air conditioning two hundred square feet of space, and three kilowatts of power, can now be purchased for one thousand dollars, placed on a desk top, and plugged into a standard wall outlet. In addition, it typically has four times the internal capacity and ten times the speed of its predecessor. Projections of equally sensational advances in technology during the coming decade are common (Forecast '81, 1980 & 1981).

Other, perhaps more significant aspects of information processing are also changing, particularly the sophistication of the user community. The typical administrator needs increasingly complex computing support and service, frequently involving microcomputing, graphics, data-base languages, query languages, and a host of off-the-shelf software packages. "Nontraditional" capabilities such as electronic mail, word processing or general office automation, on-line phototypesetting, and communicating office copiers are rapidly emerging. In addition, there is increasing need to distribute computing throughout an organization, and some aspects of computing are changing to accommodate the remainder of the work force. (For example, more individuals are becoming involved in computing in multiple locations, and the demand for 8–5, Monday–Friday computing services is increasing while the demand for second and third shift and weekend services is decreasing.) The trend is toward different kinds of people who will provide information-processing services in different ways and in different locations than in the past.

The basic descriptors that were once appropriate for the users of information-processing technology are no longer sufficient. As technology moves rapidly from the fringe areas of ten or possibly even five years ago into the mainstream of college and university activities (perhaps with computers ultimately becoming as common as calculators and telephones), the requirements for executive understanding and action change. What should we watch out for? How will technological services be provided? How will changes in technology affect institutional management?

Factors Affecting Technological Innovation

Several computing activities are maturing swiftly. This rapid maturation has been caused by a combination of events, not the least of which has been the large-scale integration of electronic components and improved price-performance ratios. Of more significance, however—and the real reason the great impact of new technologies is only now beginning to be felt—is the increase in knowledge about computing by large segments of computing-user communities. Thus, perhaps the most significant factor to watch is the growth of personal computing and computing literacy within the university as it endeavors to keep pace with the geometrical growth outside.

Computing literacy. The number of people becoming directly involved with computing as an extension of their personal and professional lives is rapidly increasing. The trend is being reinforced by the natural increase over time in computing center support, by the availability of relatively easy-to-learn languages such as SAS, SPSS, Mark IV, and EASYTRIEVE, and by at least three separate but related phenomena: the availability of relatively inexpensive home and office computers, the growth in the number of computing programs in high schools and elementary schools, and efforts by colleges and universities to establish computing literacy programs for students and faculty.

The cycle of increasing computing literacy is different for the professional than for the student. For the professional, the model is one of self-improvement, the cycle frequently commencing when he or she begins to work with computing reports. Knowledge and understanding of computing capabilities expands as the professional makes requests for modifications to reports and comes to understand why they can or cannot be filled. The literacy cycle may at some point involve programming, analysis, use of report or query languages, and use of home or office computers. Whatever the level of involvement, the passage of time serves to increase the number of professionals able to meet their own needs for computing services. It is not clear, however, that through the self-improvement model the number will ever increase at a rate which will enable the supply to catch up with demand.

Students are presented with a different model. Computer-based learning, no longer an unusual aspect of the curriculum, involves a wide variety of activities—including programmed instruction, drill and practice, dialogue with computers, modeling and simulation of educational or real-world activities, and instruction in the skill of computer programming. The question no longer appears to be whether to integrate computing into the curriculum but rather how, how much, and at what level. Computing and computing literacy programs already exist in preschools, elementary schools, and secondary schools (Swigger and Cambell, 1981; Bandelier, 1981; Lewis, 1981; Johnson, Anderson, Hansen, & Klassen, 1980; Luehrmann, 1980), and several postsecondary educational institutions have policies designed to provide *all* students with some exposure to computing during their tenure as undergraduates (Nevison, 1976; Magarrell, 1981; Gallie, Lochmüller, Poss, Ray, Rousseau, & Smith, 1980).

It is possible that future generations of students (beginning perhaps within the next five years) will be more literate about computing than most college and university faculty and staff are today. Seventh and eighth grade students may have programming skills roughly equivalent to those of today's college freshman, but where they will apply their literacy is not so clear. We might speculate that at least one impact will be to decrease the need for user offices to employ professionals solely because they are literate in computing. While it is unlikely that the overall shortage of professional computer personnel will abate in the near future, it *does* appear possible that there will be more personnel available who are discipline trained and who have some computing expertise as part of their credentials.

Office automation. In recent years, vendors have made significant advances toward the goal of providing technological solutions to office problems. While care must be taken not to provide data-processing solutions to what are essentially office automation problems, it is clear that many technological advances provide benefits to both areas. There are parallels: the general miniaturization of electronics; networking; placement of computing-like characteristics in office key-entry (typing) machines; provision of local, large-scale electronic storage of text and data and of local random access to stored information; distribution of these technologies to individual offices; and development of "user friendly" software to make the technologies work.

Many of the problems are also similar. The term "office automation" has become a euphemism for many requirements and functions, some unique to the office environment and some similar to (but distinct from) functions carried out in a computing center.

Text preparation, editing, and storage are the most common office-automation activities. Capabilities exist, however, which significantly extend the text management functions: for example, automatic spelling verification, electronic document distribution, and electronic filing. Other automated functions include calendar management, reminder systems for dates and events, electronic mail, communication with host computers in order to retrieve data for incorporation into text, and local record management and processing for use in the preparation of reports or the production of data for inclusion in textual materials.

The key questions to ask word-processing vendors are similar to those to be asked of data-processing vendors. However, in addition to the questions about basic functions, cost, reliability, maintenance, and capacity, one needs to ask about the word processor's capabilities to communicate with other office machines and host computers (with what protocol?), the ease of use by secretarial and professional-level personnel (user friendliness), and the capacity for expansion.

Given the similarities between office automation and data processing, it is reasonable to ask whether computing personnel should be assigned responsibility for college and university office automation functions. The answer is probably no. The office is a unique environment, and analyzing its functions requires unique expertise. Pure data-processing solutions would usually be incorrect and could actually cause negative reactions by office personnel to technological innovation and make future efforts at innovation more difficult.

Because of the similarities, however, it *does* make some sense for computing personnel to be involved in an office automation task force. Most computing center managers now have some expertise in networking, machine-readable files, backup, and the basics for making technology productive: compatibility, expandability, and maintainability. Those involved in office automation need not reinvent all the solutions nor make all the mistakes that computing management has made during the past twenty years.

Access patterns. There is some question as to whether the distinctions between academic access and administrative access to computing will remain. Trends in office automation, distributed computing, and fairly universal installation of computing terminals all suggest that future access to computing will be less restricted and less formal than in the past. It would appear that the potential exists for a computing user, whether clerical or professional, to decide on an ad hoc basis whether a telephone, calculator, word processor, or computing terminal is the appropriate tool for the problem of the moment. Perhaps several functions will be possible from a single keyboard.

Access to academic computing facilities is ad hoc in character. Managers of such facilities prepare for peaks and valleys in volume—periods of extraordinarily high or extraordinarily low activity. Access to administrative computing, in contrast, has been characterized by a formal, scheduled sequence of events—payroll being run on Monday, accounting on Tuesday, admissions on Wednesday, etc. Except for restrictions because of interdependency or high volume, one result of distributing the computing function to individual offices will be to place the scheduling decisions in the hands of individual users. The access problem may be exacerbated, however, by two fundamental differences between the academic and the administrative user: (1) administrative users tend to work from eight to five, with an hour off for lunch and (2) the jobs that they run tend to require more attention and consume more resources than the typical academic computing job.

Users may, therefore, want to consider the access problem when they evaluate options for future computing services. (Several of the options available are discussed in the service models section of this article.) They may want to question the present and planned capacity of the host computer vs. the limited capacity and restrictions of a desk-top computer; the availability of off-the-shelf programs or the office vs. use of host computers; and the problems of obtaining trained personnel, service, and training for the office computer vs. the relative absence of these problems if computer services are provided at another site.

The people problem. We reported earlier that growing computer literacy has been a significant factor in the integration of technology into higher education. However, there continues to be a shortage, at all levels, of qualified personnel who are capable of dealing with computing activities. A manager deciding whether or not to become involved in "locally owned and operated" computing or programming should consider the problem of acquiring qualified personnel.

Any issue of *Computerworld,* a weekly trade magazine, contains twenty-five to thirty-five pages of advertisements for all levels of personnel. The shortage is universal and in higher education includes computer science departments, academic computing services, and administrative computing services. Furthermore, salaries for computing professionals typically fall outside standard college and university salary structures, resulting in problems of training and retention. Searching for a Ph.D. in computer science is equally frustrating; the United States produces about 200 Ph.D.'s annually, roughly equivalent to the number of openings which appear during the winter and spring in any single monthly issue of *Communications of the Association for Computing Machinery,* the journal read by most computer scientists.

While the shortage is seemingly an academic problem, its significance should not be overlooked by the administrator. The shortage in industry affects higher education in two ways: it makes it more difficult to attract already qualified personnel and to attract individuals to *train* future personnel. Thus, the shortage of some types of computing professionals may worsen in the future, with students who would normally pursue the Ph.D. electing to leave academe in favor of better research and state-of-the-art opportunities in industrial settings. This phenomenon is one of "eating our own seed corn."

Two additional factors may cause the problem to become worse. First, *we* increasingly see computing as a tool of the professional administrator and researcher, but computing is becoming a tool for *many* professions. Not only is the number of computing applications within traditional fields expanding, the number of *fields* which use computing as a basic tool is also expanding. The second factor is the projection that the data-processing service industry will employ fully one-third of all programmers by 1985 (Orwick, 1980). (This problem is discussed in more detail in the next section.)

Finally, the required level of expertise and the associated scarcity of personnel is also a function of the service model that one selects. In general, more complicated models require more sophisticated and, correspondingly, more scarce and expensive personnel. Programming in SAS or EASYTRIEVE requires little training or sophistication. More of both qualities is required to program and maintain a data base, and finding a systems programmer who will maintain a system on a user-owned and operated minicomputer is next to impossible. Thus, prior to selecting a service model, serious consideration must be given to the availability of appropriate personnel.

Service models. Several models for computing services are available. Although they are not mutually exclusive (a combination of the models actually being in use in many cases), it is convenient to separate the models into three categories: completely centralized, distributed, and external. Each model has its own areas of application.

The centralized model. This has been the model of choice during the last two decades, and it typically involved a single, central site which provided computing services for the institution. (However, a model is considered to be centralized even if, because of the complexity of the institution, academic and administrative services are provided by separate organizational units or by separate installations.) The resulting structure usually involved a single relatively large staff, centralized control, and one or two computers with operating systems which attempted to provide a full range of services. Such structures still have their place: typical examples include large research projects, large administrative applications involving significant computing resources, and those applications that require a large support staff.

The centralized model was appropriate during this period because of technological factors (networking not being sufficiently advanced for general use), economic factors (computing hardware being too expensive), and performance factors (the relationship between costs and performance not being linear). The computing power that could be purchased increased almost exponentially in relationship to cost, and colleges and universities chose to invest their available resources in ways designed to obtain the most computing power and capacity. One result of the large central configurations was that computing systems were designed in like fashion—users being expected to send their information to a central computing center for processing and to obtain all of their computing services from the central facility.

The distributed model. One impact of the changing cost of technology is that the old price-performance ratio has become, or is rapidly becoming, linear. The economies of scale that were possible when purchasing computing power ten years ago simply no longer exist. As a result, it is reasonable to install sophisticated computers in relatively remote areas. This concept, coupled with more sophisticated users and more sophisticated networking capabilities, has permitted colleges and universities to consider decentralizing their computing facilities.

The name applied to this concept is "distributed data processing," which is defined as the implementation of a related set of programs across two or more data-processing centers or nodes (Sherr, 1978, p. 25)—that is, some of the computing capacity and/or processing involved in a given application is carried out in more than one location. The intensity of activity at each location may vary. The distributed activity may, for example, be limited to data entry, or "local" micro, mini, or maxi computer processing for a given application may be distributed over a wide geographic area. The model chosen is a function of an organization's structure, needs, and range of applications.

What to distribute? Rockhart, Bullen, & Leventer (1977) break an organization into "logical application groups" and consider the systems development, systems operation, and systems management functions for each. Their approach is one of considering the organization as a total entity and of distributing the necessary components of computing in appropriate quantities to appropriate levels within the organization. Buchanan and Linowes (1980) prefer to consider areas of *managed* activity. They segment computing into execution/development and execution/operations and consider the necessary controls for the management of each. In either case, distributing computing involves more than simply placing a component of machinery in a user location.

The question of what to distribute can be segmented into development, operations, and management. The questions related to systems development involve how much design responsibility, programming responsibility, implementation responsibility, and maintenance responsibility to distribute. The answers involve more than the impact on a particular user area. Those applications which affect multiple units within an organization should be developed centrally, while those which affect a single user may be developed in a distributed fashion.

A similar set of questions relates to systems operation: How much edit and control, systems updating, processing, and reporting should be distributed? The questions in the area of systems management relate to the amount of planning, control, and acquisition to distribute.

The external model. The final service model involves the acquisition of services external to the university. If asked, most computing managers will be more than willing to talk about their application backlog—that set of projects requested of computing services but not yet complete. A two-and-a-half- or three-year application backlog is not atypical. Colleges and universities increasingly are looking for alternatives to meeting the demands for computing services. Frequently, the lack of trained staff and the dual problems of staff turnover and changes in institutional priorities make what would normally be a six- to twelve-month project into an eighteen- or twenty-four-month job.

One approach to the problem has been to purchase off-the-shelf software for some of a university's more sophisticated applications. Ryland (1979) reports on a sequence of proprietary (available at a cost) software packages. It is not uncommon to find packages that would normally take six, eight, or even ten man-years to develop available for less than $100,000 (apparently a bargain at twice the cost).

This bargain can turn into a financial albatross, however, if the purchaser of the software is unwilling to accept the package as designed. All too often, a university will evaluate a software package and purchase it with the intention of modifying it. If the modifications are extensive, the university may ultimately invest more money than if it had chosen to develop the entire system in-house.

These packages are available from what has become known as the "data-processing service industry." Orwick (1980) observes that this industry is growing at the rate of approximately 20% per year and that it will employ approximately one-third of all computing programmers by 1985. In addition to off-the-shelf packages, the data-processing service industry offers a range of other services including facilities management, contract programming, consulting, and data processing.

The questions of what services and how much of those services to purchase externally cannot be answered easily. Factors which influence this decision include the size and complexity of the application backlog, the availability of trained personnel, the general level of satisfaction with the existing situation, the strength of institutional management in dealing with computing problems, the need for uniquely structured (vs. "turnkey") services, the time frame in which the problem exists, and of course, the levels of funding available for the purchase of external (vs. in-house) services. Bellamy (1980) observes that a contract with a facilities management group might provide the impetus for an organization to develop realistic goals, objectives, and priorities for its computing activities.

Technological change. Technology and its rapid change quickly become familiar topics to any who choose to enter the world of computing. The sequence of brief comments in this section about the range of technological activities is designed to provide a perspective on the rapidity and breadth of technological change rather than a detailed analysis of the impact of each change. In addition, this section contains a brief review of several articles which discuss, generally in lay terms, the nature of technology and technological change.

In recent years, *graphics* has received almost explosive attention, the adjectives describing it covering a range of activities and causing some confusion about the use of the technology. *Color* graphics is now common, as is *interactive* graphics (used within classrooms and laboratories). *Batch* graphics is also still in substantial use, its formats ranging from output on flatbed plotters to computer printouts from statistical packages. Applications of graphics include computer-aided design and manufacturing in engineering, architecture, data analysis, graphic arts, publishing, language instruction (with special characters such as Chinese and Russian), music composition, interior design, and real time monitors. Costs can vary from a few thousand dollars to fifty or one hundred thousand dollars per unit.

Videodisc coupled with programmed intelligence may provide a tool for management, although its precise use is not clear. Administrative applications have not yet appeared in the literature, but the variety of instructional and research applications which have been reported suggest a level of interest which will probably continue.

Essentially, the technology of videodisc involves combining the freeze frame, random access, and general presentation features available on commercial videodisc equipment with the programmed intelligence available on inexpensive microcomputers. The result is a wide range of new and exciting, typically nondigital applications. Examples of academic use include data-base retrieval in art history (1,000 slides) and urology (5,000 slides), instructional applications in architecture, dance, and gynecology, and research and testing in psychology, pathology and radiology (Sustik, 1980).

Networking is a solution to some, a problem to others. When machine intelligence is distributed throughout the university (terminals and personal computers in faculty offices and individual dormitory rooms; automated libraries and offices; "local" high performance networks) and throughout a community or state (terminals and personal computers in homes, businesses, or farms; interactive home computing services; public information services), networking appears to answer the question of what to do when (not *if*) the need arises to have all this distributed intelligence talk to itself.

The problem is how to construct the network. Many technologies exist which can be adapted: coaxial cable, locally installed telephone wires, the telephone system, fiberoptics, microwave systems, satellite systems, and additions to existing radio and television networks. Unfortunately, few of these technologies are directly compatible with existing computing equipment, and fewer are compatible with each other. The result is a cloud of confusion complicated by rapid change and conflicting vendor claims. The totality and magnitude of the problem are frequently misunderstood.

Finally, *very large scale integration* (VLSI) of electronic circuitry is having a significant impact on computers of all sizes—maxi, midi, mini, and micro. The popular and inexpensive personal computer is only one facet of the almost revolutionary changes in size and capacity. The impact is being felt across a spectrum of industries, and results are seen in our watches, calculators, automobiles, ovens, robots, satellites, telephone systems, and in a seemingly endless variety of other items that touch us on a daily basis.

A number of good, well-written, and relatively easy-to-read books and articles are available for those who are interested in additional details on technological trends or in a more complete description of the capabilities and potential of information-processing technology. Frazer (1979), for example, has written a paper which contains a relatively complete menu of the technological trends most likely to affect the information-processing profession through the mid-1980s. Major sections on large-scale integration and storage technologies, optical fiber technology, and satellites are included. The reader can gain some sense of the nature and potential applications of such advances as charge-coupled devices, microprocessors, and bubble memory. A good bibliography is also included.

Clark (1980) has published a paper which introduces the theory, fabrication, and operation of integrated circuits. It is organized so that difficult sections may be omitted without the loss of continuity. Perhaps most startling is Clark's observation that the integrated circuit revolution is nowhere near its limit. There seem to be, he says, "no fundamental obstacles" to developing chips which contain *one hundred million* transistors, up from 2,000 in 1971 and 30,000 today (p. 339).

The symbiotic relationship that has evolved between robotics and computing suggests that the messages in Friedrich's article (1980) fit well within the purview of computing literacy. Perhaps most significant are these predictions: that by 1990 50% of the labor in small-component assembly will be replaced by automation, 15% of all assembly systems will use robot technology, and the development of sensory techniques will enable robots to approximate human capability in assembly (p. 83). The key concepts are reprogrammable, multifunctional, and as in other areas of automation, available at reduced cost ("to an estimated $10,000 each").

Finally, the National Academy of Sciences (1979) has published a book which presents the status and direction of much of American science and technology. The chapter on computing (36 pages) is divided into sections: Current Technology and Systems; Software; Theoretical Computer Science and the Contribution from Mathematics; Computers and Communications; and Artificial Intelligence. In addition, some information on superconductors, sensors, fiber optics, and computer memory is contained in the chapter on materials. Some aspects of the chapter on computing go well beyond the five-year outlook—a prediction, for example, of student-machine English dialogues in specialized subjects within ten years (p. 248) and a comment that "there seems to be a conceptual barrier to the eventual synthesis of intelligence in machines" (p. 249).

Conclusion

Typically, one of the first questions that comes to mind when one attempts to determine how technological trends will influence the future of institutional research is whether every mid-management person in a university will become an institutional research person doing institutional research work or whether on-site, in-office computing capacity will make the present institutional research mode easier to live with. The answer to the question is different in different universities. Factors which affect the answer range from the type and quality of computing services presently available to the inclination of individual institutional researchers to become involved in computing and office automation activities. Frequently, university politics significantly affects the situation.

One needs to examine the fundamental nature of institutional research activities when investigating to what extent trends in technology will have an impact on the kinds of services that institutional researchers provide and on the manner in which they present their services. Data collection and maintenance, for example, should probably be centralized if departments throughout the university are involved or if a great deal of communication among a few departments is required. On the other hand, if only a single department is involved, the function probably can be distributed.

Similar guidelines apply for standard data reporting. Reporting activities which gather data from a single source and disseminate to a single audience might be distributed in a cost-effective manner. When activities involve research design or modeling or when there are tasks which require structured project execution, the question becomes more difficult. Activities falling in categories which require the particular expertise available from the research profession might best be accomplished with a centralized model.

A sequence of new problems will come with the new technology. Institutional researchers who become involved in distributed computing will almost certainly also become involved in the problems of common data element definitions, documentation, software development, standards, and communications. Additional concerns will include the centralization and decentralization of data bases and responsibilities related to security, systems design, data entry, machine maintenance, inventory control, and long-range data-processing planning. The problems will be more complex than in the past because coordination will be required with the management of university data centers and of other units which are also involved in distributed computing.

Finally, however, the implication is one of involvement on the part of institutional research. (In fact, institutional research is already involved in many universities.) The questions presented in this article, therefore, relate primarily to the questions of how much and what kinds of involvement—questions that can be answered only in the context of a given environment.

The variables which describe the world of computing are in a constant state of change, and these variables involve more than basic advances in raw technology. The factors which are changing range from the sophistication of computing users to the availability of a range of computing services from organizations external to our universities. Computing is a labor-intensive enterprise, and it should not be surprising to the casual observer that it is the quality and availability of personnel which will have the most profound effect on the rapidity with which technological change is incorporated into our colleges and universities.

Declines in cost and the distribution of technological power—whether it be office automation or computing—will certainly speed the technological innovations which so many seek. Individuals are cautioned, however, to resist the temptation to purchase technology simply because it appears to be inexpensive. The variety of factors and hidden costs which exist should be thoroughly evaluated as part of the decision-making process.

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The *AIR Professional File* is published by the Association for Institutional Research, 314 Stone Building, Florida State University, Tallahassee, FL 32306. Distributed as an insert to the *AIR Newsletter,* the *Professional File* is intended as a presentation of papers which synthesize and interpret issues, operations, and research of interest in the field of institutional research. Paper authors are responsible for material presented. The editor is Richard R. Perry, Associate Vice President for Academic Affairs, The University of Toledo, 2801 W. Bancroft, Toledo, OH 43606.