DOCUMENT RESUME

ED 061 992 LI 003 663

TITLE	Computing in Higher Education 1971; Successes and Prospects; Proceedings of the EDUCOM 1971 Fall Council Meeting and Conference (Ohio College Library Center, The Ohio State Univ., Columbus, Ohio, October 14, 15, 16, 1971).
INSTITUTION	Interuniversity Communications Council (EDUCOM), Princeton, N. J.
PUB DATE	72
NOTE	127p.;(26 References)
AVAILABLE FROM	EDUCOM, P.O. Box 364, Princeton, New Jersey 08540. ($5.00 members, $6.00 non-members)
EDRS PRICE	MF-$0.65 HC-$6.58
DESCRIPTORS	College Libraries; Colleges; *Computer Assisted Instruction; Computer Programs; *Computers; *Computer Science; Conference Reports; *Higher Education; Library Automation; Library Networks; Universities; University Libraries

ABSTRACT

The seventh annual Interuniversity Communications (EDUCOM) Council Meeting and Conference was designed as a forum at which some of the successful applications of computing to higher education could be examined and discussed. Particular attention was given to those applications which seemed to have wide applicability, and to those which might be useful at smaller colleges which have not had the resources to conduct their own experiments with computer applications. Four panel presentations followed by the opportunity for small group discussions of the issues raised during the panel presentations was the format for the conference. The panel topics were: recent advances in the state of computer technology, computer systems for university planning, successful computing systems in instruction, and successful applications of computer technology to reducing costs and increasing the services of libraries. This proceedings is composed of a collection of the panel presentations which have been edited by the speakers. The conference program and participants are included as supplements. (Author/NH)

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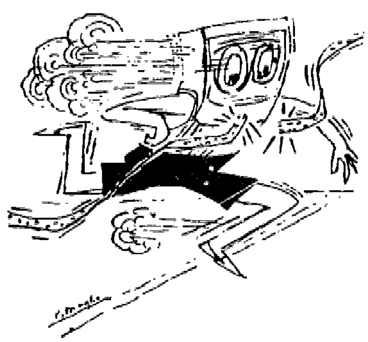
Computing in Higher Education 1971

SUCCESSES AND PROSPECTS



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Proceedings
of the
EDUCOM 1971
Fall Council Meeting and Conference

October 14, 15, 16, 1971
The Ohio College Library Center
The Ohio State University
Columbus, Ohio

LI 003 663

EDUCOM
The Interuniversity Communications Council, Inc.

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Foreword

The winds of change are blowing through the halls of academe and nowhere is this more apparent than in its computer centers. During the last decade, computing in higher education has grown from a powerful but infrequently used tool for data analysis in limited areas of research and administration to become an integral part of the normal research, administrative and instructional activities on most college and university campuses. Computing has become so much a part of the academic scene that it is hard to realize that the stored program digital computer is less than three decades old. During its relatively short life, development and change have been almost constant factors in academic computing.

In the spring of 1971, when it became evident that financial and other pressures had brought academic computing to the point at which yet further changes would be required, EDUCOM brought together a group of educators and administrators who were concerned with the directions which this change would take. In an intensive one-day session, the extent and nature of the problems facing academic computing were outlined, many different views were aired and some agreements reached.

As a follow on to this conference which looked primarily at problems, it seemed appropriate to examine some of computing's successes and its prospects for the future. There have been many experiments in applying computing power to administrative, research and instructional problems. Some of these experiments failed, some were successful only at a single institution, and some were successfully transplanted to other institutions. At some institutions, and for some purposes, mini-computers provide a cost-effective solution; at others, networks have been used successfully; at yet other institutions, the traditional computer center still appears to be the most effective means of providing the necessary computer power.

The Seventh Annual EDUCOM Council Meeting and Conference was designed as a forum at which some of these successful applications of computing to higher education could be examined and discussed. Particular attention was given to those applications which seemed to have wide applicability, and to those which might be usable at smaller colleges which have not had the resources to conduct their own experiments with computer applications.

Over 180 persons attended the three-day conference which was held at the Center for Tomorrow on the campus of The Ohio State University in Columbus, Ohio. Two members of EDUCOM, the Ohio College Library Center and the Ohio State University were hosts for the meeting. Four panel presentations followed by the opportunity to discuss in small groups the issues raised during the panel

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presentations was the format for the conference. The panel topics were: recent advances in the state of computer technology, computer systems for university planning, successful computing systems in instruction, and successful applications of computer technology to reducing costs and increasing the services of libraries. Conference attendees were welcomed by Novice Fawcett, the President of Ohio State University. At the banquet held in conjunction with the conference, John Millett, Chancellor for Higher Education of the state of Ohio gave the principal address. In addition, conferees had the opportunity to visit a wide range of interesting computer applications in the Columbus area before and after the conference itself.

The panel presentations have been edited by the speakers and are collected in the following pages. Further information concerning any of the systems described by panel members can be obtained by writing directly to the author of the presentation. Names and addresses of all the conference participants are listed at the back of this volume.

I would like to take this opportunity once again to thank Jim McKenney and the members of his Program Committee for the excellent program which they developed. I also want to thank all of the participants for their part in the success of the conference and for the promptness with which they have reviewed and returned their papers.

Henry Chauncey

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Introduction

At a time in which the costs of computing have been receiving more emphasis than its benefits, the Seventh Annual EDUCOM Council Meeting provided an opportunity to examine and discuss some of the achievements of computing in higher education. The Conference "Computing in Higher Education: Successes and Prospects" held in conjunction with the Council Meeting, gave participants a chance to exchange ideas, share successes, and learn about promising developments. The papers presented at this conference have been assembled here so that even wider distribution can be given to the concepts and developments which were discussed.

The Conference was organized about four panel presentations: the first exploring recent technological innovations which seem to offer improved productivity of computing resources; the second reviewing various methods of using the computer in college and university planning; and the third and fourth examining successes and problems in instructional systems and library management. Each of these panel presentations is preceded by an overview prepared by the panel chairman.

In his welcome to Conference participants, Novice Fawcett, President of Ohio State University, stresses the need for the exchange of information and experience among colleges and universities and clearly indicates the importance of meetings such as this as a means of facilitating this exchange.

Robert Taylor sets the key note for the opening panel by emphasizing advances in technology which are making the small computer faster, cheaper, and more convenient than remote reliance upon a large, general purpose computer. Peter Lykos describes a mini-computer system being developed at Illinois Institute of Technology which also offers a small college access to a national or regional network.

Robert Rapp presents a case for the larger computer and describes how he presently uses the ARPA Network to access the 360/91 at UCLA for number crunching and the 360/75 at the University of California at Santa Barbara for data analysis. Through the ARPA Network, researchers in universities and university-related centers will be able to tap the resources of the ILLIAC IV. Rapp describes how he intends to utilize the network to conduct meterological simulation in three dimensions and to utilize the laser storage of the ILLIAC IV for weather data analysis. Barry Wassler expands on the idea of the computer network as an alternative to the traditional computer center for some institutions. The cost savings through use of the ARPA Network which he indicates gave rise to a great deal of comment and discussion by other Conference participants.

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The second panel looks at successes and problems in using computers for institutional planning in colleges and universities. Ben Lawrence describes the prospects for long-range planning. He notes the lack of operational systems needed to create the data base for planning, the *ad hoc* nature of present university planning, and the reservations of many planners concerning the possible misuse of information contained in institutional and state data bases as critical issues facing long-range planning in universities. Ronald Brady characterizes a management information system as a structure for planning and evaluation which will make "what has happened well known and what will happen well planned." He, too, comments on the difficulty of making long-range plans with an inadequate data base. He suggests that faculty participation is especially necessary in short-range planning. George Turner re-emphasizes the need for real faculty involvement at all stages of university planning if planning is to be successful. He warns particularly against the practice of developing two independent plans for a university's future — an academic plan made by the faculty
different assumptions and arrive at totally different results.

James McKenney describes an information system developed to aid in the operation of an educational program and to generate simultaneously relevant planning data. He emphasizes the planning necessary to generate such a system and the long elapsed time for the accumulation of information.

The third panel discussion focuses on the successful application of computing systems to instruction. Donald Bitzer and Wilson Judd describe the Plato IV and TICCIT systems, both of which are supported by NSF as demonstration projects investigating alternative means of providing computer-assisted instruction. Plato IV uses a large computer with many special purpose terminals while TICCIT makes use of a mini-computer with ordinary TV sets as terminals. Michael Hall summarizes the successful development at Beloit College of a combined administrative and instructional system using an IBM 1800 and Teletype terminals. The system is easily adaptable for use on an IBM 1130. Administrative uses pay for the complete system thus the instructional uses can be supported at no additional cost. Beloit College offers complete details and available instructional packages to anyone interested in replicating the system. Rex Kureger describes the computing center at the University of Colorado which is organized as an auxiliary enterprise, like a bookstore, and is returning money to the university over and above its costs. The computer center is primarily a service organization with limited research responsibility.

The panel agreed that the major issues which will affect implementation of computer assisted instruction in the future are: changing technology which could radically alter the cost structure of computer assisted instruction, overcoming the non-transferability of much of the instructional material being developed, and the necessity for careful analysis of the processes of instruction and the development of learning objectives prior to producing new computer-based instructional materials.

The last panel discusses the operations of the Ohio College Library Center and the Ohio State University Libraries. Fred Kilgour describes the successful efforts of the Ohio College Library Center to use technology to reduce the costs of library operations. OCLC has an on-line computerized cataloging system in operation. Members are cataloging new acquisitions on line with catalog cards produced in virtually any format desired by the individual library. The operation will pay for itself and return $400,000 annually to members from the cataloging operation alone. Gerry Guthrie gives a good picture of the computerized circulation system in operation at the Ohio State University Libraries. The system permits a user to charge out books by telephone and have them delivered to an on-campus address. The success at OCLC in reducing operating costs for member libraries and the success of the Ohio State Libraries in providing greatly increased services through its computerized circulation and catalog information system provide excellent examples for future library automation in universities.

John Millett's address summarizes the views of an administrator toward the problems of utilizing information systems in higher education. He stresses the value of the computer in providing the necessary information for effective decision-making that emphasizes that good information does not relieve the administrator of the responsibility of making decisions. Dr. Millett's remarks bring together the general themes of the Conference in a most practical light.

As typical of most meetings, the significant activity was individual groups discussing the topics or analyzing counter examples. Three conclusions seem to emerge from these discussions which on reflection may substantiate the gathering as one of the more positive mutations in university administration. All relate to the existence of successful computing-supported activities within the university community. I would characterize these conclusions as follows:

1. Implementing successful computer-based programs requires a considerable period of elapsed time, at least three years or more.
2. Computer systems impact all aspects of the university and as such pose a difficult managerial task.
3. The process of exporting successful computer developments is improving and new forms of transfer are being developed.

Hopefully, a realistic appraisal of these conclusions and active management of computer resources in light of this appraisal should lead to more computing for less money. The improvement certainly seems feasible, especially through greater cooperative efforts.

On behalf of all those who attended and benefited from the Conference, I want to thank the members of the Program Committee for working to make the EDUCOM Fall 1972 Council Meeting and Conference an effective meeting. Martin Greenberger, Frederick Kilgour, and John Lubin all devoted much time and effort to selecting topics of current interest and securing a wide variety of stimulating speakers.

James McKenney
Program Chairman

Chapter 1

Opening Remarks

by Novice Fawcett
Ohio State University

Perhaps, at the outset of greeting so courageous a group as this, I should make some formal show of respect — like bowing extra-low in your presence.

Please consider this done! Frankly, in this last year as OSU's President, I shall be so busy bidding "farewell" at such an appalling accumulation of meetings, conferences, forums, seminars, colloquiums, clambakes, and just-plain-palavers that it'd be rash to attempt extracurricular athletics in the form of bowing. Right now I'm trying to determine which daily routine must go — inhaling or exhaling.

The desire to show deference comes from my realization that you are singulary brave people. I understand that some valliant souls still mount white steeds and sally forth to slay dragons — at least figuratively; — they attack a contemporary counterpart of the mythological monster. Before me are heroes who have chosen more daring feats of valor — attacking, instead, two current monster-problems; namely dread foes of communication and thereby of universities.

You must realize that to a university president, the first-named . . . communication . . . has become virtually a dirty word. A few self-styled students have tampered with the standard definition. To them and their dupes, faculty and administrative information is labeled "lack of communication," while their shrill "non-negotiable demands" are "meaningful dialogue." You could perform no greater service than help to untangle this destructive snarl.

Then, as if wading into the multiple communication-mire were not enough, you take on "university" and, to further complicate the task, you add *inter-university!*

It is simply not sufficient to wish you "welcome" and "good luck;" civilization also should face east, and burn incense!

I recently heard a university described as an assemblage of elusive, amophous, disorganized miasmas of thought — or what passes for thought — made even less-comprehensible by the windy gobbledegook of its president.

That judgment gave me pause — very thoughtful pause! While I deny its validity, there's reason to believe that, to some people, a university is Washington, D.C., in reverse; i.e., "foggy bottom" after the earthquake and volcanic action. Certainly, therefore, the ultimate in elevated density should be a combination of universities! Frankly, there's not too much I can do about all this, but at least I can — and I shall — stick to a renewed determination to be brief.

A further service I might offer is to tell you that what, no doubt, you suspect to be true — is true. In my considered opinion, the people involved with the entire spectrum of computer services at the Ohio State University are good; They're well-trained, capable, and dedicated to their responsibilities. And that's the chief reason for my confidence in welcoming you and bidding you to make yourselves at home.

There are far too many excellent directors and assisting personnel in each area to single out, but no mention can be made of the university's use of computers without special recognition of such key people as Dr. Roy Reeves, Director of the Instruction and Research Computer Center — who has been an influential mover-and-do-er from the early days, and Dr. Marshall Yovitz, Director of the Computer Information Science Department. Within the learning resources area, under the administration of Dr. John Bonner, Vice President in charge of Educational Services, there is Mr. Hugh Atkinson, Director of the University Libraries and their "on-line circulation system" — unique in the world's major research libraries. There is Dr. Ronald Christopher, Coordinator of the University Computer-Assisted Instruction Program which is undergoing phenomenal growth. Assuredly of interest is that the funding of this CAI service is entirely a university commitment. The spectacular success of innovative programs introduced by the college of medicine results from the team efforts of a great number of its bright, hard-working faculty and the fine leadership of its Dean, Dr. John Prior. They include the health center's automatic book stack system, operated by the libraries' remarkable mechanism. When completed next year it will be the country's first medical library to possess such a service. Second, and perhaps even more exciting, is the sole pilot medical school in existence, to my knowledge, which — at this date — is enabling 89 selected students, on a volunteer basis, to benefit from independent, individualized learning through three years of computer-assisted, computer-monitored research study.

Recognition is due Mr. Carroll Notestine, Director of the Unique Learning Resources Computer Center, especially for his outstanding motivational accomplishments with MEDLARS; and to Mr. George Baughman, the University Budget and Administrative Research Director, for his successful handling of the inevitable payroll, scheduling, and student-grade-card complexities. Extra-special recognition is due Mr. Frederick Kilgour, Director of the Ohio College Library Center, to whom all involved look for assistance. Professer Charles Csuri and his spectacular computer art are adding a new dimension to the scope of computer potential. And so on — and on — throughout a long, stellar list!

Only a cursory reading of your agenda for this meeting convinces me that you're going to be busy. Even so, I have a request. Please see to it that attention is directed to elimination — or reduction — of some of the bo-boos which are bound to plague most any fresh endeavor. As a matter of fact, and from one who knows by experience, they seem bound to bedevil most any complicated endeavor, whether newly-hatched *or* hoary with age!

Even though the matter well may come to attention in one or more of the proposed topics, I found throughout your agenda no specific mention of discussions about mechanical goof-offs which further embitter many members of a society which seemingly is destined to encounter additional harassment from devices installed for the purpose of helping it. Let me mention just two for-instances brought to my attention. You probably could add a few more. There's the faculty member who for some time was hounded by computerized demands that she return a library book which she not only had not withdrawn, but had never even heard of. It didn't help that, judging from the title, she'd rather not hear of it. There's the honorable, upright gentleman who finally was bullied into accepting a $96.98 credit against a New York department store for two lawnchairs which an irrational computer insisted he had returned. The distraught man had neither seen, bought, nor received them but, after exhaustive, repeated attempts to set the record straight, he wore down. He gave up!

This plea that you concede mishaps and bend every effort toward de-fusing them, comes from a man who is on record as providing strong support for university use of computerization — one who continually becomes a more-ardent advocate.

I also am very aware of the necessity that all of us who in any way share in responsibility for the well-being of civilization be constantly alert to the dangers which accompany our well-intentioned inventiveness — the need to make sure that all advances serve humanity, not the other way 'round. I imagine you know that universities have considerable, and not unpublicized, cause for concern on this score. While such obligations have always been of prior importance, at no other time have they been more consequential — or more demanding.

A gathering of this nature, composed of responsible people, superbly qualified to help us all reach such a goal, is a very bright source of hope for us, and hence for mankind.

I cordially welcome you to the Ohio State University — adding only a fervent prayer that outstanding success may attend your endeavors.

Chapter 2

Computer Technology: Recent Advances in the State of the Art

OVERVIEW

by Robert Taylor
Xerox Palo Alto Research Center

Several basic points were identified by panelists discussing recent advances in the state-of-the-art of computing. Concerning mini-computers three ad-vantages were highlighted. First, small computers today are faster, less expensive, and more reliable than those previously available. Users can now get many services from a small processor which previously were available only from a large general purpose machine.

Second, much of the use of a university general purpose computer center is in fact not general purpose but a great quantity of short computations with heavy I/O. In a great majority of the cases, students and faculty use the computer as an improved desk calculator or as an accounting machine.

Third, the small computer can be used effectively to access large remote systems and to prepare input and process output from the larger systems.

Improved library systems connected through networks will make available to scientists two capabilities which are not possible on the smaller computers. First, the volume of data which can be generated and stored using systems like the ILLIAC IV will be greatly increased once these systems are operational. Second, the ability to analyze and use large quantities of data and to analyze the data in a three dimensional manner will be available with the combined computing power of several large machines connected by a network. Robert Rapp described his plans to utilize the ILLIAC IV in connection with the IBM 360/65 at Rand in Santa Monica, a 360/91 at UCLA, 360/75 at Santa Barbara and the ILLIAC IV at the Stanford Research Institute.

The advantages of obtaining computing from large systems over a network were advocated especially enthusiastically by one panelist, Barry Wessler from the University of Utah, Computer Science Department. He cited the example of a test case simultation which revealed that University "Y" could save $1 million per year by obtaining all the computing presently derived from a 360/65 on-campus over the ARPA Network from UCLA's 360/91.

The specific advantages of both mini-computers and large systems connected by a network and the possibilities for utilizing both through a network arrangement are outlined in the following papers in more detail.

COMPUTER TECHNOLOGY: SOME IMPLICATIONS OF RECENT ADVANCES

by Robert Taylor
Xerox Palo Alto Research Center

As computer users, we are beginning to see more small processors which are faster, less expensive, and more reliable than previously available. These machines are "small" primarily from the standpoint of costs, ranging in price from $5K to $50K with primary memory (core, bipolar, MOS) from 4K to 32K words. We are continuing to receive more memory for the dollar with MOS and bipolar integrated circuits making inroads on core. Some integrated circuit manufacturers are expecting to be able to deliver MOS memories during the next year which are 60% the cost of corresponding core memories. Terminals continue to be a problem primarily because the qualities and completeness of any particular terminal are quite application dependent. High performance, quality terminals with full color, vector, and character generation capabilities still do not exist.

Current technology suggests that university computing planners should give as much attention to the campus-wide distribution of small, dedicated machines as is given to the centralized so-called "general purpose" computing center. A close examination of the university general purpose computing center will reveal that while the university is indeed paying a premium price for the computer's "general purposeness," it is in fact not using the center in a general purpose manner, in that a great majority of administrative, student, and even scientific computations are short and tend to be I/O bound rather than compute bound. The relatively small population of the university community concerned with large number crunching computation (usually a few physicists) would be better served with their own special purpose machine, thus allowing the rest of the community to take advantage of the cost-effectiveness realizable through small, distributed systems. Forty mini-computers at twenty-five thousand dollars each are equivalent to a single million dollar central facility in cost, but are roughly ten times more effective in processing capability. Finally, in the interest of education and relevance, small machines should be made more directly available to the student, thus reducing if not eliminating the welfare line outside the central, closed shop, computing center.

HIERARCHICAL COMPUTING — A COMPUTER SYSTEM COST/EFFECTIVELY OPTIMIZED FOR EDUCATION

by Peter G. Lykos*
National Science Foundation

Information,
Its form and flow,
That's what makes
Society go.

The invention of the information processing machine, together with concomitant developments in automated hybrid electromechanical mass information storage devices and in computer interfaces to telecommunication common carriers has made possible a large enchancement in our ability to handle information. At this point a logical question to pursue is: To what extent is the large potential for improving the common weal, which has been made possible by this new technology being realized? The answer, unfortunately, is hardly at all.

The problem arises from the fact that the new technology, which permeates every area of human endeavor, has come on the scene too rapidly. Society, given its current systems of formal and continuing education, cannot react as quickly as new technology is developed.[1]

Education has failed to meet its responsibility of incorporating new technology into instruction. This indictment is particularly severe in the case of the universities. One reason for supporting graduate research is to ensure that the academic program at the undergraduate, as well as at the graduate, level is optimizing the preparation of the student-youth of today to be the effective citizen-adult of tomorrow. If state-of-the-art technology is ignored or insufficiently used in undergraduate and graduate education today, scholars, professionals, and government officials will be technologically illiterate tomorrow.

A currently accepted myth maintains that the young research-oriented instructors, recent Ph.D.'s who know "how the bits flow" in a complicated computer system, and who have convenient access to a sophisticated large-scale university computer system, are going to lead us to the promised land. The example of W. Pillsbury at Knox College, Galesburg, Illinois, shatters that myth.

With many years of experience in teaching Accounting and Economics in a small liberal arts college, Prof. Pillsbury used an elementary subset of a common computer language to develop a number of simple computer programs to run on a mini-computer in order to augment the courses he taught. He was able to demonstrate a marked enhancement of the instructional process as well as update course content with a mini-computer restricted to batch mode with alphanumeric display.

The faculty of our colleges and universities may follow the example of Prof. Pillsbury and others and discover how the information processing machine is enhancing the effectiveness of the problem-solvers and decision-makers of our

*The opinions presented here do not necessarily represent policy of the National Science Foundation. (See *Computers in Instruction*, RAND, July 1971, p. 47) society. They may transform accordingly the curricula they have designed and are implementing.[2] In doing so, however, they will discover another obstacle to incorporating technology into instruction. The computer support faculty have available generally are industrial, commercial, and research-oriented systems with patch-on token support for students.

Student computer support systems are jury-rigged for fast batch processing using a very restricted set of languages (and corresponding processors) which, among their many shortcomings, further perpetrate the gross misconception that "computing is mathematics." Such systems generate very impressive "statistics" about how many student programs are processed. Very little is said about the substantiative impact of those programming exercises on the student's professional development.

Unfortunately, the information processing machine is still viewed as either a giant desk calculator or as a super accounting machine. Too few have recognized that a combination of both those technologies, enabling students to simulate and model-build using data files taken from reality, constitutes one significant step toward the new technology accords us.

Another step forward is the use of the information processing machine, operating in real time, interfaced to servo and senso devices. One example is data logging (including signal noise filtering) and control in experimental laboratories. Another example is many students at terminals, each sharing a computer resource in interactive or conversational mode.

In November 1969, an article brought a current awareness of computer hardware, software, and firmware technology to bear on the questions, "After Token Academic Computer Use — Then What?"[3] Certain realities were brought to the surface, namely:

1. There are 23,000 public high schools, probably 8,000 private ones, 2,300 community and four-year liberal arts colleges, and 250 multicollege, multidepartment universities where the average liberal arts college, taken as a norm for that set, is spending about $60,000 per year for administrative and educational data processing support. The financial data base for such data processing support is firmest in support of administration data processing.
2. The NSF sponsored Regional Computer Networks, the ARPANET, the airline reservation system, commercial computer time-sharing utilities, the FCC ruling data communications activities, and the MITRE community computer support system which employs CATV with a touch-tone-telephone input and home-TV output all suggest that the incorporation of the information processing machine into our informational technology is fast becoming a cost/effective reality.
3. Conversational, or interactive, computing has not only become cost/effective for small problems but also is more satisfying to the man at the man-machine interface. Punched card input and line printer output is no longer adequate, even with the turn around time from a community terminal reduced to zero. Restriction to alphanumeric representation of information, labriously and noisily typed out at a rate far less than that possible for the computer to produce it, or the human to assimilate it, is also no longer necessary. Cathode ray tube display, with graphics capability, supported by comprehensive and interactive

data file handling and display capability is cost/effectively here today.

4. The so-called mini-computer has been driven down in cost. As a component in a computer system with mass storage and input and output peripheral devices, it accounts for a small fraction of the total cost of the system. In fact, a recent ACM publication,[4] considered for discussion the world of the zero-cost 4K 16 bit processor. The man-machine interface requires physical proximity of the man to the input/output devices, but telecommunication obviates the need for physical proximity at the machine-machine interface. We need a re-examination of what equipment needs to be installed locally and what equipment (including software!) can be shared remotely, capitalizing on economy of scale.
5. Generally programs are best used on the computer system for which they were written. Innovators in the use of the computer in the several problem-solving and decision-making disciplines devise algorithms which they implement on their campus computer. Usually (and especially with no financial inducement to do otherwise) their programs are not transferable to other computers on other campuses. Computer program exchanges, although well intentioned, have generally not worked.

A problem regarding computer support for education has been part of a general problem the computer consumer has faced, namely, what the manufacturer makes, the customer takes. Several universities at different points in time have chipped away at this problem of adopting the computer vendors' systems for education. With the advent of the mini-computer it seemed timely to take a fresh approach by setting down education-serving design goals that would take into account the several factors outlined in the foregoing.

In 1970 Illinois Institute of Technology began developing the IIT Computational Laboratory based on a mini-computer supporting CRT terminals, mass storage devices, and a communications interface facilitating access to other computers elsewhere.

Recognizing that no computer vendor had yet produced an optimal computer system for secondary and higher education using state-of-the-art hardware, a system design was conceived and a Request for Bid sent to over 100 vendors dealing with mini-computers and corresponding peripheral devices. The specifications for bid included "intelligent" CRT terminals with graphics capability. The vendor finally selected agreed to maintain the *entire* system including some of the peripherals which were supplied by other vendors. Even though a major price concession was obtained, the vendor agreed to replicate that price for any other non-profit academic institution. Furthermore, the vendor agreed to assume full documentation and maintenance responsibility for the software which would be created at IIT.

The details of that system including actual costs were given in the Fall 1971 issue of the EDUCOM Bulletin; however, briefly, the system has the following features:

1. The mini-computer capabilities are fully utilized. A classroom full of students, scheduled there for that purpose, have interactive computer support from CRT terminals with graphics capability. In addition to a super desk calculator, algebraic interpretive compiler, and symbol

manipulator, there is capability for sophisticated file handling.

2. Access to a larger machine is provided. The instructor can dial up a distant computer in order that his students may use a program written by some remote innovator for his local computer. Furthermore, the process is made as transparent as possible by incorporating in the software the control card and reformatting requirements of the remote system.
3. Local storage devices are available. Local mass information storage devices permit the generation and use of large files, necessary for many substantive uses of the computer in local or stand-alone mode, including CAI. Additionally, the students have the low cost option of small magnetic tape computer program and data portability as well as hard copy alphanumeric and graphic output.
4. Administrative data processing is provided. The administrative data processing is supported for both data processing in local mode as well as remote-job-entry access to large utilities elsewhere.

The central processor for the IIT systems has been simulated in IIT's large computer, the UNIVAC 1108, to facilitate software development. However, the entire system at the moment must be regarded as a gedanken experiment since the capitalization has been held up by litigation. The experience to date with other similar software development lends considerable credibility to the system design.

The foregoing has suggested one of the important roles to be played by the mini-computer in higher education. As Dr. Taylor touched on most of the important points regarding mini-computers themselves, I didn't dwell on the machines themselves. I trust that some of the remarks advanced here have been provocative and I hope our discussion session this afternoon will enable you to share the information and knowledge you have so we may present to the community at large some of our best thinking on the role of the mini-computer in support of education.

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1 "Future Shock," A. Toffler, 1970.

2 Prof. Pillsbury's programs "CompuGuide One" and "CompuGuide Two" are available for general use and have been published with text under the title *Computer Augmented Accounting*. Over 186 schools are presently using these programs on ten different computers. CompuGuide Three and CompuGuide Four will also be available after March 1972 from the publisher, Southwestern Publishing Company, 5101 Madison Road, Cincinnati, Ohio 45227. Charges for both text and programs are nominal.

3 Educational Media; Nov. 69; Feb., Sept. 70.

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COMPUTER TECHNOLOGY APPLIED TO METEOROLOGY

by Robert Rapp
RAND Corporation

My purpose here is to talk more as a user of computing power than a computer scientist. I'm not a computer scientist, nor am I an educator. I'm a person that's concerned with trying to use every bit of computing power we can beg, borrow, or steal in order to try to do a fairly complex job. I would like to try to share with you some of the problems and successes we have had so far in this project.

Now, the problems of meteorology have always been a driving force in computing development, always driving to bigger, faster machines. Not so much in the economic sense, but they have continually posed problems which have pushed computer people to bigger, better and faster machines. Incidentally, I'm not on the mini-computer side; I want big, large machines. The late John Von Neuman was the first to recognize the potential for the computer in the field of meteorology and we have been pushing hard on that problem ever since. The specific job we're trying to do right now is to look at the determinants and the dynamics of the world's climate, why it is the way it is, and more importantly, how it might change. We can't go out and tinker with the atmosphere so the next best thing is computer experiments. Needless to say, this takes a lot of computing. And it falls into two categories; "number crunching" and "data massaging." We do a tremendous amount of number crunching but we then have to go back and look at all the numbers we produce and try to make sense out of them. I'd like to go briefly over these two parts to our problem and try to show you where the ARPA network and some of the machines that are in use there have contributed.

The basic model we're using was developed at UCLA by Mintz and Arakawa. It's a set of coupled non-linear partial differential equations, together with a whole host of what we call diagnostic equations. After the prediction is stepped forward — and incidentally, it goes six minutes at a time — we have to go back and evaluate the consequences of the altered flow pattern, such things as computing the vertical velocities or looking at the data to decide whether a thunderstorm has formed. There is a whole host of such diagnostics. The model works on a sperical grid at two levels, five degrees of longitude and four degrees of latitude, for a total of about sixty-four hundred grid points. With six minute time steps, it takes half an hour of computing time on the IBM 360/91 to simulate one day. There's a hope eventually to be able to simulate not days but decades but the best we've been able to do to date is about two months' simulation. We are presently working most on a 360/91. We are looking forward rather impatiently to the ILLIAC IV. We're expecting, from the estimates we've gotten to date, to get about a factor of sixty in computing speed — that would help some. But I should also add that we already have planned to go to a finer grid, more levels and add in an ocean circulation model which would run under the atmosphere — that would just about eat up any gain that we get from the present version of ILLIAC IV.

We're actually running experiments with the atmosphere, making changes and then looking at the results, and it's the looking at the results that gets us into the data massaging business. It takes just a very few punch cards to change the basic input to the model. One of the experiments we've run is to try to find out what would happen if the ice were removed from the Arctic Ocean. Well, you change a few data points and that's easy. But then you start running the model and even though the program goes in six minute time steps, we only save data every six hours. The data is produced at the rate of one standard IBM disc pack per month of simulated time. So far in our experiments, we have accumulated about thirty such disc packs full of data and it's no small task to try to look at this vast amount of data and decide what really is important. And here is where we think that the ARPA Network and some of the newer machines will be of help. It doesn't look as though the ILLIAC IV is going to help us with our data massaging at all, so what we want to do with that machine is to produce large batches of data then we want to ship that data to another machine which will enable us to look at it. There are no hard and fast rules as to how you look at this data. We are in the process of developing methods and techniques, and these are all highly dependent on having a man in the loop. He's got to be able to get an idea, then look at the data, and refine his ideas. It's a continual feedback situation. We have implemented some simple coding languages to retrieve and display data on the Rand videographic system. Right now we have been doing this via the ARPA Network using the 360/75 at Santa Barbara as the basic analysis machine. The initial transmission of data from UCLA to Santa Barbara was a Volkswagen network — we put two disc packs in the car and drove them up there. Now UCLA is on the network and we believe we will have a three-way communication where we will use UCLA's 360/91 to do our number crunching and the 360/75 at Santa Barbara to do most of our data massaging.

That much is the kind of thing we're doing with the simulated data. We also would like to look at the real world. People have been gathering weather data for years and years and years, long before computers. Obviously, much that was gathered before electronic data processing is on paper and on maps — it's just impossible to try to recover that data. ARPA has set aside ten percent of the trillion bit store which is to be installed at Ames with the ILLIAC for a weather data base. We've been through the possibilities and ten percent of that storage device — that's ten to the eleventh bits, — should store about ten years of weather records. Providing we don't try putting in there all of the information that the satellites are pouring out. That is still beyond the possibility of storing and saving.

Our success so far has been that we have gotten onto the network and are successfully using a set of three computers. They're all fairly local; one is our own at Rand an IBM 360/65, a 360/91 at UCLA and a 360/75 at Santa Barbara. We started this a few years ago when the communication between Rand and UCLA was by taxi cab; as I say when we first brought Santa Barbara into the picture, we could talk to them about problems but we couldn't send data to them so we took that up in a Volkswagen. But as of right now we have successfully used the network to both enter our jobs and do the number crunching and also to retrieve the data, bring it back, display it on a video console and decide what we want to do with that particular data. We hope that we'll be on ILLIAC next year; we are looking forward to other locations getting on the network. There are some beautiful programs written for the 7600 at the National Center for Atmospheric Research. We'd like to use those in addition to our own and so we're continuing to try to push in this direction.

Our big problem is that we are trying to run a scientific experiment, if you will, concurrently with the development of the system. Things are improving all the time but it's a little unnerving to know that the way you do it today is different from the way you did it yesterday and as sure as shooting, tomorrow there's going to be some changes made. It would be nice to be able to sit back and say "This is how we do it." We can't afford that luxury. We need the power, we need to keep ahead of the game and I think that's something that all of you will face sooner or later.

DUMP THE COMPUTER CENTER

by Barry Wessler
University of Utah

We have talked previously about going out over the ARPA Network to obtain special computing services like to the ILLIAC, Trillion Bit store, MULTICS, etc. It is possible thereby to obtain some services that weren't available before or that are orders of magnitude cheaper. This type of use is becoming familiar to current nodes on the ARPA Network. At the University of Utah Computer Science Department, our principal computing system is a time-shared PDP-10. There are people at our project who are doing two and three dimensional fluid flow analysis of Blood Flow in an artificial heart. The work involves solution to partial differential equations. This type of calculation is much better handled in a batch environment. It really fouls up our interactive service on the 10. We are now in the process of moving them off the 10 onto another machine on the Net better suited to their type of calculation, probably the 360/75 or 91. There is good justification for this economically and it is proceeding very well.

But there is another probably more important possibility for hardware sharing or what might be considered more accurately "Hardware Using." That is to do away with the Computer Center completely. Do away with the Computer Center, its director, its system staff, its headaches, its cost overruns, its deficit financing, and its petty politics. As you can probably see, I'm not a great fan of Computer Centers. Once you have thrown out the Computer Center it is possible to obtain the computing services required by the university from the Network; from universities that weren't smart enough to throw out their computer center or from a commercial service when they are available over the Network. Not only can you obtain both batch and time sharing services, but you can get batch service from systems tuned to batch processing and time sharing services from systems tuned to time sharing.

Access to the Network for these universities would be through a device called the TIP for Terminal IMP. The TIP allows consoles and other I/O devices to have direct access to the Network. The TIP is a combined IMP and data concentrator. It does not perform any computation. It has a small language to tell it where to connect and, what properties the connection should have — (Full or Half duplex, line or character oriented, etc.). The TIP will support a variety of terminals — Card Reader, Card Punch, line printer, and magnetic tape unit for batch and Remote Job Entry type services and teletypes, IBM selectric terminals, CRT's and simple graphic stations. It is capable of handling 64 terminals of up to 2000 bits per second each. Like the original IMP it requires no mechanical mass storage devices for its operation, thus the reliability is expected to be very high. Two TIP's have been delivered and four more are expected in the next several months. There is some talk of packaging the TIP in some large empty IBM boxes so that prestige minded university administrators can still show off an impressive looking facility as well as finally boasting of a self-supporting rather than self-servicing operation.

The nice thing about the TIP is that it is not dedicated to one particular HOST. One user can be talking to a PDP-10 while another is simultaneously talking to the 360. Service on the remote machine may have been purchased on an individual basis or may have been contracted by the University in an overall account. Other than the cost of the TIP and the Network no money is expended until a service is used.

There has been a test case. University Y performed an analysis of their computation needs. They had a 360/65 and looked in their analysis for the right direction to go in the future. They spend about $1.5 million per year on computation. After long discussion and analysis, they learned that the same computation can be obtained from UCLA's 360/91 at 1/3 the cost or $.5 million per year. The communication traffic was analyzed and shown to be well within the constraints of the ARPA Network and the TIP device. There was therefore an immediate savings to University Y of $1 million per year if they chose this direction. The cost of joining the Network and obtaining the TIP is estimated to be $75 K per year. After this carefully detailed and exemplary analysis the decision was made to proceed with the installation of their own computer system once again.

The moral of this story is that before this kind of analysis is evaluated it behooves the university administration to fire the Computer Center director and everyone else who has commitment to the current way of doing business.

Chapter 3

Computer Systems for University Planning

OVERVIEW

by James McKenney
Harvard Graduate School of Business Administration

The panel on Computer Systems for University Planning presents descriptions of actual computer-based planning systems. Panel members are individuals who rely upon such systems to aid universities in planning.

The four speakers represent widely varying environments and perspectives in approaching this topic. Each view is offered as evidence of the success of such systems in a variety of environments. Further, in considering such a complex activity as university planning and computer support, one has to develop one's own concepts. This is a sample of different views to help build that concept.

Ronald Brady describes the approach to planning and budgeting he has advocated at Syracuse University and suggests that faculty participation is especially necessary in short range planning. Without faculty participation, the right questions may not be asked or answered and forces that will shape university development may be ignored.

Ben Lawrence emphasizes the interface issue. Information systems are being developed for use in long range academic planning, but there has not been a corresponding development of operational systems which can generate the data base which the planning and information systems require. Dr. Lawrence also notes that systems now being developed for long range planning reflect a concept of planning which is radically different from the traditional university view of planning as an *ad hoc* process.

George Turner brings to the panel the experience of an administrator trying to do planning with an inadequate data base. He reinforces the contention that better operating systems are needed to create the data base necessary for long range planning and agrees that a crucial ingredient for both long and short range planning is faculty participation.

James McKenney describes the steps in the development of an information system which can support a computer-based planning effort. The system itself was developed to control costs and to assist in the allocation of basic resources of the Harvard Business School. The planning effort was articulated by the development of a simulation model of the School's activities concurrent with the system development.

COMPUTER SYSTEMS FOR UNIVERSITY PLANNING

by Ronald Brady
Syracuse University

Planning can mean many things! I personally feel, that at least in my concept, the planning function has been conspicuously absent in higher education for at least two decades. In some cases we have deluded ourselves into believing that planning was taking place by the development of a so-called "master plan." There are so many obvious and fundamental differences between planning from a management standpoint and the typical form of general guidelines usually developed as to make the case trivial.

Planning is the management of change! As change accelerates, so too must the capability and use of planning. The single reason why the challenge to management is so pressing on our campuses today is due to the speed at which unplanned change is occuring, and with that the quite observable chaos created by a lack of organized processes to accept and control the change. When the rate of change is so rapid, and when no processes exist, there is a psychological impact on the people in the process which is both severe and understandable.

Planning involves participation, and if systematically handled, facilitates understanding. Planning involves both long and short range views. It involves testing alternatives and developing "full" costs. It means that systems are developed to produce information and, systems are implemented which provide for control and evaluation on a close to real time basis although the words are badly misused. A management information system is absolutely essential. Systems do not replace management, but there can be no management function without same.

Further, system and information needs require some form of handling a large volume of data: while obviously not essential computers are quite helpful.

I feel that one of the fundamental misconceptions about the use of computers in the planning process lies in the area of design. A great deal of effort has been made which sometimes lead administrators to conclude that the proper use of computers is in the development and design of a sophisticated information retrieval and handling system. One is led to believe that when such a process is available, all the many inherent "truths" of the complicated interrelationships among the planning variables will be discovered. And further one is led to believe that once the questions of management can be accommodated by this process, then "optimization" can be determined.

I believe this concept to be incorrect, but in many ways I argue that more use can be and should be made of systematic procedures and computer processes.

For the moment, let me use a definition of a Management Information System which I find useful.

> "MIS is a structure for planning and evaluation such that what has happened is well known and what will happen is well planned. It evolves participation and analysis and provides for interaction and communication. It facilitates understanding."

To have what has happened well known means a variety of things. It means there are operational processing systems which produce accurate, timely, consistent and complete information. It is not fashionable to concentrate much on this area today, and that is too bad. The single area where computer applications are the most needed are in this realm. It is not an exaggeration to state that very few of the administrative operations on the many campuses are in great shape. Data Systems are not interrelated! Output from most systems are not sufficient to explain the event or contribute to the planning function! I am sure most of us could spend a considerable amount of time discussing this in detail. Current systems, on most campuses, in virtually every data system are still geared around processing considerations, not around the need for comparison, evaluations, forecasting, or control. Management information systems are built from the bottom up, with the pieces all relating to the objectives of the overall design.

Moreover, there are still considerable economies to be achieved in costs by systematizing many of the semi-manual processes. A combination of "achievable" economies and the need to provide the first and fundamental step toward an MIS produces a vast area of need for systems development and the use of computers.

To have what will happen well planned involves several things. In the first instance, and the second *fundamental* element of MIS is short run control and analysis. It is essential that the operational systems provide control over what is currently happening and over what can happen during the short run conditions as expressed [usually] by the current years budget. Monitoring and performances evaluating processes do not exist in any appreciable form or sense, in most systems. It is in this area that models are of the most use. It is acceptable and reasonable that short run [continuation] projections can be modeled. The internal structure of the current budget is in desperate need of modeling. Not to find inherent truths, but to understand in great detail the impact of changes in FICA or Workmen Compensation, or utility rate increases. It is necessary to be able to explore the impact on various possible decisions about salary increase, fringe benefits, insurance. The heroic assumption of "all other things being equal" is not so heroic in the very short run. However, to use such models to predict, or to use such concepts to simulate long run development is absurd. Heavy additional use of computing capability can be of great benefit in this area. In fact, on a campus of any size the need is close to essential.

Computers can be of some direct use in long range planning but not a lot. Needless to say, however, if the previously discussed condition of adequate operational systems *and* of central and short run forecasting are not achieved, then every pretense at long range planning is just that.

Long range planning in the arena of higher education involves a host of complex considerations. The demographic, sociological, economic, political, and attitudinal considerations are endless. My own staff of analysists recently told a joint session of regional, county, city planners that we [the University] have data which can be used to support any set of outcomes anyone would like. That [statement] is not completely untrue.

However, the problem with determining the validity of a set of assumptions does not and may not preclude the need for developing program evaluation and planning techniques. One of my personal "pet" projects is the use of participative planning and evaluation by using PPBS [or whatever name you like].

Direct computer applications are not yet very relevant, but as said many times, the input is essential.

The management function, and the associative planning function, for higher education require systems and the analysis of vast [hopefully] amounts of data. The foregoing is a *brief* overview of one person's thoughts on the need and use of computers in this process.

AVAILABLE PLANNING METHODS FOR UNIVERSITIES AND COLLEGES

by Ben Lawrence
Western Interstate Commission for High Education

I'd like to explain what the National Center for Higher Education Management Systems (NCHEMS) at WICHE is doing so that you will understand our perspective in very bread sweeping terms. I'd also like to raise three issues that are currently facing us in the application of modern management concepts to higher education.

What is NCHEMS doing? We are primarily concerned with improving management capability in institutions of higher education. Now that's a broad definition, to be sure. More specifically, we're trying to do this through the application of modern management information systems to improve our decision-making capability by enabling us to examine alternatives, and we're focusing more specifically on the resource allocation problems as it relates to program planning. We're not covering the entire gamut of management because we simply do not have the resources to do so.

Specifically, we're trying to improve the management capability of institutions of higher education, and we're focusing very narrowly on the application of computer systems to the resource allocation and program planning problem.

The first of the issues I want to discuss is the interface issue: How do you get the data that are needed to work in the area of management planning. The National Center for Higher Education Management Systems is in the intriguing position of having advanced the state-of-the-art in management tools and systems applications ahead of higher education's development of operational data systems. We have developed some sophisticated models that under certain kinds of controlled environmental situations work rather well. Unfortunately, when we proceed to implement these models and systems in institutions of higher education, we discover that institutions lack the capability to provide the data in the format that we need — readily available, up-to-date information. When you put random numbers into the system, you get random numbers out, and that's not much use in making decisions in higher education. We have increasingly turned our attention to the problem of the interface between operational data systems and management systems. Unfortunately, we do not have resources to devote to this problem, but if we're going to do much in the area of management, our first order of business will have to be the development of operational data systems that can be used in the management and planning processes.

The second issue that's confronting us is an issue in the truest sense of the word because we must determine the direction in which we will move. The use of the word "system" frightens many administrators in higher education because they think of a system as having a beginning and an end and no intermediate stops. Many don't really understand what goes on between the beginning and the end. They tend to view systems as a black box. When we think of planning for an institution of higher education, we become very concerned about the concept of applying systems to the planning process. Planning for the most part is *ad hoc* in nature; you have a problem, and you must resolve it in the context of the overall goals of the institution. Consequently, it is an *ad hoc* exercise at a specific time, and you resolve that issue and fit it into your overall scheme. Another problem arises, and you've got to fit that into the overall scheme. In one sense planning is a process and it implies system, but the forces impinging upon the planning process are crisis and *ad hoc* in nature. Therefore, when we look at systems and we have the notion that they're not flexible, we become concerned about the advisability of using a system approach in planning at all.

Out of this kind of discussion have come requests from our National Advisory Panel and particularly from One Dupont Circle, asking what our system looks like? Some of our people in institutions of higher education are arguing that we will define that shortly, and they have been working for two years trying to define what the system looks like. Other people are saying, "It isn't a system; it's a workshop." By this they mean that our "system" is a number of unrelated tools or computer programs or concepts available to a team of artists who are attempting to resolve a particular problem at a particular time. They bring their problem to the workshop much in the way that a cabinetmaker brings wood into the workshop. He forms the wood by first doing something with it on the bench saw, then he runs it through a shaper, and finally he uses a sander to get it into the mold that he wishes. Many people are arguing that we should not refer to the application of systems to the management of institutions of higher education in systems terminology. We ought to talk about an analytical workshop in which problems of a planning and management nature are brought not into an assembly line factory but into a workshop that does custom-made problem solving. The dilemma is unresolved because systems people like to think of a system that can flow smoothly; the administrator tends to think of himself as an artist and wants to interrupt the system in order to do his particular thing.

The third issue that I want to raise is a particular problem to us at the National Center. Institutions fear, often with justification, the uses and misuses of management information that flows from this kind of activity. Institutions have reason to believe that state systems, systemwide operations, state legislators will pick up some of these *ad hoc* tools and use them inappropriately in ways that they were not designed for. There is some justification for this fear, and questions are asked from time to time: Shall we go this route? Shall we develop management procedures that are compatible from institution to institution and from state to state? Shouldn't we develop instead management systems that are unique to each institution and do not have the capability of this kind of cross institutional line comparison. The argument is that if we develop comparable measuring techniques in the management area, if we develop comparable tools, information is certainly going to be misused to make illegitimate comparisons. This is an issue that is currently very much alive among our participating institutions, and it is an issue in which state governments in particular are getting involved. How it will be resolved remains to be seen.

DEVELOPING PLANNING GUIDELINES IN A LARGE UNIVERSITY

by George Turner
University of California, Berkeley

We start with Ben Lawrence one of the leaders in planning in higher education, who is trying to push all of us, to carry all of us, to lead all of us — and if he has to, to get our state legislatures to do it — to lead all of us into better planning. He is dev' ing some very sophisticated tools to do it. Where does he run into trouble? If you remember what he said, he's got to have the data. He can devise the planning tools but universities can't use them because universities don't have the data. Then we come to Ron Brady sitting in the administrator's slot. He's about halfway between Ben and me. He's got the day-to-day problems to face at the same time as he's trying to devise the long-range plan. If he is really lucky, when he's devising the long-range plan he can make use of some of the tools that Ben has been able to provide for it. Then there is me, developing the data bases that are supposed to be supporting both of these kinds of things: the data bases that Ben needs in order to use the tools that he's developing; the data bases that Ron needs in order to figure out what is going on right now so he can make some reasonable projections about what may happen tomorrow, so that he can then make some very unreasonable projections about what may happen next year.

Now let me quote to you a statistic from a corporation that I know rather well. They're about the same size as the University of California, about a billion dollar corporation. They have fifteen people in their planning staff. They spend on their management information systems staff, developing operating systems whose mission is among other things to provide information about what's going on right now and information to do long range planning, fifteen million dollars a year. Fifteen people supported by fifteen million dollars a year. Now, think of a university in that sense. The universities that I know of have perhaps ten percent of the faculty and maybe two percent of the administrators worrying about planning. That's, for a billion dollar corporation, maybe a thousand people. And they spend perhaps three million dollars on their systems staff to get this data. There's something wrong there — one of us has got to be wrong. One of the problems, as I see it, is that universities are wrestling with planning, rightly or wrongly, in a different way than corporations are wrestling with planning. Universities have a very kind of unique situation; they have a faculty that is heavily involved in where they're going. They have, like corporations, a whole range of operational systems that support where that university is going to go.

But let me paraphrase an academic administrator who is now the chief planning officer for a large university. He said "We go to these planning review board meetings and hear a presentation of the academic plans. It is generally where the faculty would like to go and what new schools they'd like to have, what new departments they'd like to start, how well the ones that they started last year are doing. Then we come back and in about two weeks the Budget Director prepares a set of charts with numbers on them. Sure enough, those numbers look much like they did last year, except that perhaps he's thrown in one new school here. That goes up to the next higher echelon where they say, 'I like those numbers but I just don't like the bottom number — reduce it.' Then the analysts go to work trying to make the columns balance to the bottom number which is now reduced." He said, "It occurs to me that perhaps the faculty might think that they weren't involved in this process." In fact if you follow the process, the faculty aren't very involved in the process. On the other hand, the faculty are the ones who are running the place — they're the ones who are making it a great university or not a great university.

So we have a terrible dichotomy here; we have insufficient support to the first line administrator with data he needs to know to determine what is going on right now, and much less for the long range planner who is trying to project the whole program through time. At the same time we have the operating faculty members, who are the key to the whole organization, generally not involved in the process whatsoever.

Now how do we get over this? Remember my bias; I'm trying to develop operating systems to satisfy both of these needs. I know corporations are spending about five times as much doing what I am supposed to be doing. I am in an organization that nominally has something like three hundred times as many planner as the corporation did.

The only way that I see that we will get out of this position is to make a different kind of commitment to the way that we do our planning. First, let's see if we can't get the faculty members buried in the middle of the real financial planning that's going on. Let's not have two plans, a financial plan and an academic plan. They don't look alike, they don't talk in the same terms, they don't come up with the same bottom lines, if one of them does have a bottom line. At the same time let's make that resource commitment, the long-term, expensive, time consuming resource commitment to get that data that is the only key to getting to where we want to go.

Now let me take a short moment to speak about what I mean when I say "that data." In my view there's no such thing as a management information system as most of the literature conceives of it. There is such a thing as a base of data from which a few talented analysts can answer some questions, either short range questions to handle Ron's problem or long range questions using the tools that Ben is devising. But there is not a management information system that by itself answers these questions. Now, what goes into this base of data? Most universities design computer systems because they want to automate their payroll or they want to improve their registration system or they want to get funds from their alumni. Whatever is the largest felt need yesterday is the work that goes on today.

How often do people sit down and say what is the data that I am going to need? On students I'm going to need to know data about who gets admitted. Good! That is admissions so I'll just turn some people loose on an admissions system. That isn't the data that you're going to need. You may need to know who wanted to get admitted, who thought that he wanted to get admitted but were sure they could not. You may need to know how much money their parents can pay, how much money his parents *think* that they are going to have to pay. When it turns out that they think it's going to be more than is actually required and therefore he doesn't apply, you have an individual in society who, because the perception is wrong, has literally lost out. He has lost because *your* data system didn't give your managers the capability to change that perception in the marketplace. Is marketplace a strange term? Corporations look at the marketplace all the time and further they look at the perception of the marketplace. Universities, at least in my view, seldom think of the marketplace, much less the secondary thought of the perception of the marketplace. External data is often much more valuable than that internally generated. An admissions system should often be more complex than just who has applied to the university.

What about the alumni? What's an alumni system for? Obviously it's to find out information about your alumni. Particularly to get money from them. But what is going to tell you whether your university has done your job right? That's a kind of a long range plan. That's the kind of a thing that Ron has to depend upon. Did the student, when he left the university, make use of what he received from the university? Did he? Did anybody ask him? Did anybody build an alumni system that could handle it? Isn't that a key question?

The critical point of this is that systems which are so necessary to build for operations are also the base of data absolutely necessary to the planners who are going to have to answer the questions like: How do I structure my university to meet my marketplace? What do I provide my students when they're here so that they benefit after they leave? The planners *must* work with the operators to begin to think in terms of not today's problems but the kinds of data necessary to answer tomorrow's problems.

The systems are really very, very simple if thought about in a different way. If planners begin to ask the right questions and if planners begin to work with operating people to seek the right answers, the system is seldom complex. It's easy. It is so simple that terminals and mini-computers are almost science fiction in comparison. But unfortunately, I don't see these kinds of questions being asked, even now. The wrong questions asked; the resources committed in the wrong directions and not enough are being committed. Worse, even if we had the brightest guys asking the right questions, we would continue to have a horrible organizational planning problem to involve the faculty in helping us do that kind of job that we're talking about.

COMPUTER-BASED SYSTEMS AT THE HARVARD BUSINESS SCHOOL

by James McKenney
Harvard Graduate School of Business Administration

This discussion will be focused on an information system development to aid in planning and resource allocation at the Harvard Business School. A fortunate aspect of this development is, like the cobbler's children, the Business School had no computer system of any integrated nature as of 1967. Thus we had a clean slate. In that year a committee was formed to look into how best a computer system could assist the Dean in planning for the future and at the same time support the educational process of the School. The Harvard Business School, although it is just one entity in the total University, is a reasonable-sized institution of 2,000 students and over 200 Faculty. Further, it operates completely independent as far as the specification of its internal financial statements and student records. At the outset, the purpose of the committee was to pool insights, set goals, and perhaps establish some priorities of what needed to be done first, in order to achieve a working system that would support the students and assist the planning effort. It was an Advisory Committee reporting to the Director of Computer Services, who in turn reported to the Associate Dean for Educational Activities. As such, it met at periodic intervals over a year to develop the proposed system. Out of this series of meetings, a four- to five-year plan came into being. As of the Fall of 1971 the plan is not implemented completely for reasons of economy, personnel change, but most important new insights on how to accomplish our goals easier.

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Three projects were initiated to allow an operational system to be developed as a base for planning. The first project was the definition of a data management system design; the second a financial reporting system and the third, the development of a simulation model to serve as a planning aid. The projects were selected as the most critical elements in the long run, easiest to start independently and the ones which could be used to test the total design concept.

The alumni file was on tape and a file of over 30,000 records. It was a working management system which needed to be redesigned to orient it to random access data management system. It was felt the economics of such a system would far pay out the development costs and, further, the experience of developing such a working management system would provide a good background. The system we envisioned was a complete file on present student, and alumni, and faculty in a readily accessable form. As the alumni file would accumulate and grow, it seemed to be the dominant file design problem. The alumni format could be used in developing a student format which would be useful from the time of admissions to when the student became an alumnus. The goal of the data management system for the alumni file was to gain experience in the development of a file such that it would aid in the design of an admissions system, a registration system, and an on-line student access system. All of the files were to produce planning data. One early discovery was lack of consistent data to consider alternative resource allocations.

The financial reporting system seemed an important ingredient if we were to move to a more actively managed control system within the School. Heretofore, information on costs came at varying time schedules such that it was very difficult to discern at any given point in time the financial status of a program. Moving towards a monthly period of reporting forced a reasonable articulation of cost centers and developed a better discipline of cutoff dates and motivation to process bills promptly. Further, in appraising the need of a monthly report, a better awareness was sought for what were the decision points and what information was really necessary to report at period intervals versus what information was adequate on annual or quarterly bases. It was felt if a good reporting system were in place, it could serve to identify the important variables one should measure over time. These measures such as faculty workload, number of students per course and number of courses seemed useful for simulation into the future as well as on going measures of controllable activities.

The simulation model was developed as an aid to quickly evaluate the impact of possible changes. The model itself was developed in coordination with the Deans of the School to consider what issues they felt were most important and how one would characterize those in terms of students, faculty, dollars, support staff, and facilities. A great contribution of the simulation model development was that it identified the data required from operating statements to develop future realistic plans. Further, the model development focused attention on the leads and lags in the operation of the School to give a better over-all feel for how operations could be influenced and what were the impacts of changing student enrollments, faculty workloads, and student scholarships.

These three projects set the tone for the development of improved systematization and, where appropriate, automation of information processing within the School. None of the projects really eliminated people as much as they provided prompt service and information heretofore not accessible. Thus it allowed the same people to deal with larger student-faculty workload in a more effective fashion and reduce a few flaps. Out of this first set of projects, which were concluded in the spring of 1969, a new set of projects developed which continued the program of implementing a management system. The first of these was a budgeting system to allow each program within the School, that is, the MBA Program, the Doctoral Program, or the Executive Program, to identify the variable cost of that program. The second project was the development of an on-line faculty file to allow the Senior Associate Dean to consider alternative faculty assignment. The third was an automatic aid to the admissions activity of the School, and the fourth was to improve through automation the registration process.

There was a move in the School to consider if it would be feasible to raise tuition to cover variable costs by program, that is, the Master's student would pay their variable costs and so forth. In order to do this more effectively it was felt budgets should also be identified by program. This change in orientation allowed an opportunity to develop a new budgeting system for the School. The budgeting process was in keeping with the reporting system and was partially automated.

The more interesting projects were the faculty file and the admissions procedures. A set of files were developed for each member of the faculty which included his past teaching assignments, his future desires, and his experience. This file is accessible by the Dean from a Cathode Ray Tube. The Dean with the Area Chairmen consider a range of alternative course-research assignments for each faculty member and can instantly see the overall impact. These assignments are then discussed with the faculty and retested. Further, given a set of assig. ıents this file can be analyzed by the budgeting procedure to develop a cost per program figure. Faculty assignments, which were a basic determinant of experience levels can now be easily considered with a wide range of alternatives. Further, this file was constructed in a fashion that it provided basic data for the simulation model to allow different faculty assumptions to be made and tested on future programs the School might embark.

The admissions system implemented a commitment of the Faculty Committee to focus upon the student files as an aid to the educational process in considering the total information system. It was felt if we could create a responsive set of information on addresses, phone numbers, student background and the like, it could facilitate student organization and allow prompt response to opportunities such as visiting experts or unique field research requests. One of the biggest bottlenecks in the entire student information processing was the admissions process which is the students first exposure to the School. An ever-increasing number of admissions had to be handled within a short time frame with limited personnel. To cope with the challenge an information system was developed which maintained the status of each admittee and relevant information about the admission process. This has been one of the more successful projects. Upon submission of an admission blank an on-line file is created for a student with name, address, and list of admission steps. This file is used to monitor status of admission folders for prompt response to applicant query and appraisal by the Director of Admissions as to bottlenecks in admission processing. If an admittee calls in, his query of where his admission stands often can be handled instantly. Upon admission and acceptance a full student file is created from the admission folder which maintains the student's latest address and a record of the information sent and receipt acknowledged prior to arrival at the School. This file is relied upon to allocate housing, organize incoming students into classes and consider special requests. Upon arrival the student's local address is entered and the accuracy of the information obtained in the admission file checked, for example, new marriages, shift of home address, and the like. Students who do not show up at the admissions office are promptly contacted. An updated record of number of actual students is available to the administration.

Active student files are maintained by the Registrar to record classes, grades, extra-curricular activities, and special projects. These files are accessible only to the Registrar or individual faculty who have permission of the student. A portion of the file is accessible to the Financial Office for recording charges and payments. All of this data is then summarized by month as to charges, student activity and aggregated. A semester and a summary file of student activity is developed with course enrollment, faculty resources and incurred educational financial expenses. This data is being accumulated to serve as a basis for the simulation model and future planning. We found we had a very little codified experience upon which to make future estimates because we had not recorded past experience. We attempted on-line registration but found exceptions and student error confounding. Manual registration seems easier and more economical of nervous energy. Tracking of actual experience of both student and faculty has proven most valuable in obtaining the necessary information in machine accessible form to make quick and reasonable realistic appraisals of what is likely to happen in the future.

In conclusion we are developing an information system to aid in the operation by automating student, financial, and faculty reporting. This automation is being done in a manner to ‚elop an information base with which to support a range of planning activities. It has taken four years to develop an adequate information base, which is coupled to a reporting system which seems to indicate the reality of what is going on. We are now in the process of creating good questions to speculate about future activities.

A final comment on faculty involvement which was an important ingredient of this system effort. They not only helped in the design but worked to test the system and have contributed to its acceptance. It would appear such involvement of individuals is feasible in most faculties. Business School faculties are no different than other faculties in that they tend to be more prone to analyze data and seek information rather than synthesize information and make a commitment to action. Such decisiveness can be obtained with reasonable management, calls for an agenda, analytical staff support to the backup work and a deadline for activities. To date the Committee process has worked reasonably well in developing a design for a system to support our educational process.

DISCUSSION: COMPUTER SYSTEMS FOR UNIVERSITY PLANNING

DR. BRADY:

There are some real problems with that. For example, I had a meeting with a group of faculty recently who were commissioned by the university to develop a body of regulations about student discipline. The committee turned in their report — I might add that it took them four years to complete it and when I read it I asked them how anyone could implement such a process — they said that was my problem. Not atypical.

DR. LAWRENCE:

Relative to George's concerns, you might be interested in one of the situations that occurred with the pilot testing of one of our simulation models. We had received a very glowing report from the administrator, in fact he's the vice president of administration for this institution, about all the wonderful things this pilot testing of this particular model did for him and his institution and we were rather pleased to get this kind of a glowing report so we decided to interview him and ask him some questions in detail to see if we could get some benefit out of this for other people who were struggling with the same problems.

One of the first questions we asked him was: "Well, how long did it take you to conduct this exercise? This pilot test?" He said, "Well, we've devoted one man-year to the effort." I said, "Well, that's fine, but can you give me some indication of what kind of effort went into that one-man year?" He said, "Well, it took us one day to get the system to work on our computer." I said, "How long did it take you to get the kinds of analysis out of this thing which you had operating?" He said, "That took about one week." I said, "Well, what in the world were you doing the rest of the year?" He said, "Well, for the rest of the year we spent our time collecting the data to get it in the right format to run this thing." Well, that was sort of a disillusioning experience, but then when I probed a little further and I said, "Well now, what do you think was the biggest benefit that you got from your efforts?" He said, "Well, this model has done very great things for us; its told us what our institution looks like." I said, "Well, that wasn't what the model was for; it was to help you plan for the future." And he said, "Well, but look at all the data that we got in a format that we can really understand for the first time."

I guess the point was that the only purpose that that particular model had served in that particular institution was to provide a motivation to get data that institution needed in order to make some day to day understandings about their institution. This was rather disillusioning to us. What they really wanted was to understand what was going on. They were really, at that point in time, very little concerned about the future. They had problems to solve in the course of the next two to three weeks for which data was very useful, and the model was only the motivation to get the data.

DR. TURNER:

Let's look at Jim's comment: Why the hell don't you ask the faculty? In fact, you've got a faculty that is as highly trained as is possible to get, that is used to dealing with data for deriving conclusions particularly about future behavior. And what's our problem? We have a report that took five years in the making and that's not implementable. Where's the breakdown? I offer to you a possible suggestion that the breakdown is that the way we as administrators use the faculty is on committees merely to get them involved so they feel involved. We do not get them committed so that they really address themselves to this particular problem in the same way, with the same commitments, with the same resources that they apply to their research work. And I think that I see a pattern in the two examples that Jim mentioned: the faculty members and the administrators, and let's hope, the students are committed over a long period of time together to solve a real problem that we all have right now. We're not asking them for advice; that's the best way to get wasted time and lousy advice. We're asking them to work with us — or they're asking us to work with them, it's the same thing — to solve a problem over a long period of commitment. I think that that's the key to getting that faculty to help us to do our job better, which will then hopefully help them get their job better done more easily.

DR. BRADY:

I think that's right. Jim, I'd like to just comment on both of those points. At another meeting — we have lots of meetings — another meeting I happened to have the other day was with a committee of the faculty who are from our senate who are called the budget committee, of which I happen to be a member wearing the hat of a senate member. We spent a good three hours in my office discussing what could a committee of such do to help the budget making process of a university. This committee consisted of three or four faculty members from finance, accounting, public administration, law; and graduate students from similiar and related disciplines; and it certainly seems that on the surface that their talent could be marshalled. It is obvious these the people represent a compendium of backgrounds and skills that's in excess of a couple of our systems analysts that we have sitting around in our shops. The key is they didn't know anything specific. They had not been involved in the planning process over a long period of time and it's difficult to go to ground zero. If one looks at the degrees of freedom left in the middle of October for 1972-73 budgets, one will find that there are very few left. The buildings that are coming on line will be on line; the programs that have been approved will be implemented; there is little left to debate except how much should the average faculty salary increase be, which tends to be what they historically debate. And I don't know how you get the people involved over a long period of time. I think that is one of the questions, and Jim, I think maybe since it was your suggestion that the faculty be more involved, that you might try to answer that.

DR. McKENNEY:

Well, I think experientially I've only been in one environment where that worked and that was a three year commitment to test out how time shared computer systems could help out the the educational process. I might add that the plan was comprehensive; the activity did not work out as well as the plan. It was a joint effort to spend six hundred thousand dollars in exploring and working with undergraduates and graduate students alike, to test the value of a time-shared computer aided instruction system. Professor Ottinger and Bill Bossert and others on the faculty of arts and sciences and several colleagues on the Business School faculty had a grand idea.

In our three year program of testing computer aided instruction, our first stage was to obtain an SDS/940 Computer. We would test that system with thirty-two terminals and it would cost X. The funding would come from a National Science Foundation, from the Business School educational budget, and from the general computer fund, so each was going to pick up a third of the cost. We projected usage, the number of students and student hours, and had some neat measures on what was to happen.

The first thing that happened is the computer didn't work very well so instead of having thirty-two users we could only have sixteen to eighteen. The second was, in the middle of the project, the NSF funds dried up because the federal government had a modest change of heart. We had to go back to the Deans and say, "This well-integrated plan we put together eighteen months ago seems to have some variances right now and the variance is about a hundred thousand dollars." Having done our homework and worked with the administration, they were at least responsive. We then managed to get in a position where the people who were working most closely with the system became dedicated to the notion of extending the SDS affair. Simultaneously the users who were most identified with the students in the graduate work became dissatisfied with the system. We could not work that issue out in the committee.

The problem ended up where all administrative hassels do, in a vice president of administration's lap. Since he didn't know if the faculty were just grumbling or if they were for real, he decided in favor of the administrators; and we continued in the SDS system. Most of the faculty members, because they'd been in the argument and knew all of the idiosyncracies, went off in a great big huff. As a result the SDS system was not supported and lost money.

Now I'm raising those issues because I think that the real problem with that exercise was that it was a specific project and it was set up as solely a three year planning project with no life. In retrospect, had we had some continuing committee responsibilities and administrative involvement in that responsibility, it might have been a different story. Out of that phoenix has grown a significant faculty committee on time sharing and we now are sponsoring a good bit of educational time sharing support in the university. That's another long story.

DR. LAWRENCE:

It occurs to me that there are difficulties in involving faculty in administration problems that may result from "agenda" confusion. When faculty meets on an administration problem, either together with or separate from the administration, the agenda of each group appears outwardly to be the same, but the agenda of the administration is very often quite different from the agenda of the faculty. Agendas have to be interpreted, and perhaps in the planning process, one of the things we tend to overlook is a mutual understanding of the problem we're trying to resolve. It's been a number of years since I've been involved in that process in an institution, and as I look at it now, I see two different directions. To what extent do you feel, Ron, that you really have the attention of the faculty focused on the problem that your dealing with?

DR. BRADY:

We don't. I'd like to take about an hour to answer that question and I'll take ten minutes because it's a very relevant question. And it goes back to George's problem of what I call a tops down budget versus a bottom up budget (for all practical purposes), and that is the very difference between the two exercises that go on on the campus (bottom up) versus the legislative process, which is top down. We proposed a system to our campus during this summer to construct permanent and on-going councils for each of the major administrative offices on the campus: a council on academic affairs, a council on administrative operations, a council on student affairs and a council on university relations, staffed permanently by faculty, students and administrators, almost in equal numbers, to be further augmented by advisory panels created by each council for every department in the university consisting of the same kind of constituency — in a sense, a combination of advisory panels melting into councils in parallel to every administrative department and academic department in the entire university. And we have further persuaded our Board of Trustees to possibly reorganize, to have only four functional committees parallel to each major administrative office of the four I just mentioned. This is an attempt to focus the student and faculty members of the entire community on the real problems of today — not just a committee meeting with a different agenda; I agree with that absolutely.

I can only say so far the senate came back, we opened the school; for five consecutive weeks there's only been one item on the agenda of the senate and that's the discussion about the acceptability of this advisory panel-council conept. At this time there has been tacit acceptance of the senate and most other groups on the campus but I am sure the debate will go on for some time. The faculty and students at this point in time seem more concerned about procedural matters and the process of management instead of the issues.

DR. McKENNEY:

Let me respond. I suspect in a bizarre way professors of administration are eunuchs in the sense that they aren't real scientists and they tend to get too clinical about the management process; but, in some sense, we are professors. I'll comment on one of the things I observe in my own institution, and since I've been working with two others to try and worry about how they manage, my observation has some generality to university administration.

Let's say that I'm a corporate president and I decide that it'd be a really good thing instead of making tomato catsup that I want to make a new, exotic, distilled tomato juice. I know that it's going to take me two to three years to get the organization to accept the idea. Most good presidents start by finding some key opinion swayers, getting them in on the decision and have, if you will, long range plans about how they're going to move the organization. Some of the most powerful corporate executives in the world, that I'm familiar with anyway, don't go out at eight in the morning and say, "Next week we're going to make tomato juice."

One of the problems in faculty-administrative relations is that in a sense there is a disproportionate time use. The administration is typically worrying about economics and such things as keeping the dormitories going and the telephone service working; in addition to negotiating with the plumbers' union and worrying about snow removal. Then there is the long run red ink which Ron has asserted. Finally, at the bottom of all those very real unnerving problems, there's planning and that is somehow sometimes mixed up with the faculty. Now I assert that the role of a good administrator is not only to plan for planning but perhaps to think about how you're going to involve the faculty meaningfully. That's a delicate art. I don't think anybody understands it very well. I will say a great practicer of faculty involvement, who continually has my admiration is Howard Johnson. I don't know if many of you are familiar with this gentleman but he was the president of MIT. In the Cambridge area he tended to work an interesting phenomena during all of the student ruckus; that is, he somehow managed to get a great spectrum of opinion and keep the lid on the house. During the crisis period he seemed to win the complete support of the faculty and if you looked at it, it was a fairly long, planned effort.

I'm not suggesting that Ron has not done that. I am suggesting that faculties are incredibly obnoxious about change. On the other hand, I'm not sure they're any different from the longshoremen or a lot of other people in our culture. Change involves careful planning. I do think to get back to one of the original points we made, one of the things that has made faculty-administration cooperation, at least in the store I work, easier is finally getting some data on what it costs to educate an MBA.

About how much does a credit hour of MBA education cost the school versus a credit hour of doctoral student work? This has eliminated some — not all — of the rhetoric because a lot of the rhetoric is opinions on values. You can really say OK, here it is, it costs us on average about twenty-two hundred dollars a year for an MBA student on pure variable instruction cost with a hundred and twenty percent overhead factor added to that. This defines the cost of instruction to the institution, as about forty-seven hundred dollars a year. Now is that good or bad? I'm suggesting that if we really did have a better data base from which to discuss issues, we might have a more informed and responsive audience. George?

DR. TURNER:

Yeah, let me see if I can say essentially the same thing in a different form and maybe for some of you it will hit better. You have a computer system and you go out and negotiate with your customer on whether or not that's a good computer system and whether or not he's going to use it. That customer has heard every war story in the book; and by the time he's heard them they are comparable to a major battle which in reality was a contest between two people with one finger apiece. He has a tremendous antipathy to what you're trying to do. In addition to that, you're generally telling him that you can give him such and such a report and it will have numbers — it's got X's on it right now but it will have numbers on it, eventually. Now, turn yourself around and look at the customer's standpoint. He hates what you're doing; he knows that if he ever accepts what you're doing it's going to drastically change his way of life; he doesn't understand how it's going to change because all he's seeing is X's; and he knows you're going to fail. But in addition to failing you're going to cause him to fail. Compare this to the faculty. The faculty has spent years doing lots of discussion, trying to influence the administration to do something when in fact all that happens is that some budget analysts sit down and crank out the numbers. He knows after years of experience that he has had no success whatever and of course all the budget analysts have fouled him up and so there's bound to be failure here. In addition to that, he knows that he's talking to incompetents, just exactly the way the manager is talking to incompetent system analysts. A professor once told me that when Clerk Kerr was promoted from Professor to Chancellor of the Berkeley Campus, he in fact accepted a demotion and then when he got to President of the University, they had really kicked him to heck out. The only reasonable thing that the Regents of the University of California had done had been to elevate the man back to his original justified status of Professor. So the faculty is dealing with some people that obviously are incompetent. Now how does the systems analyst handle this? Well, if he's doing his job right, he anticipates the problem; he gets some data, so he doesn't have X's; he knows that he's facing a clientele that is at least hostile and he just plans to work in that kind of an environment over a period of time in order both to change the environment and to eliminate as much as possible of the non-useful rhetoric that he can with hard data sitting in his hand. The two things, I think, are exactly parallel operations. All I'd like to see is that some of the things which are learned by the systems analysts, if they're doing their job right. If we can learn that and apply that in our dealings with the faculty both of them dealing on an open basis, getting the facts so we can get rid of the rhetoric wherever that's possible, we *might* in the next fifteen years, get somewhere. But I think it's critical to try.

DR. McKENNEY:

Just to change the topic modestly, Ron, I'm curious, now that we've buried the faculty thing, how much use did you experience at Ohio State and how much general purpose system can you bring from one institution to another?

DR. BRADY:

All right. Can I unbury the faculty for one statement? Because I think that what everybody is saying is essentially true and I was just going to get around the circle; we'll try to in a minute. I think one of the fundamental differences between faculty administration relations in problem solving is understandable and it is tied together by information systems. Faculty typically do not function to make a decision on the basis of what they do in fact know; they are very well trained to get sufficient data. They are very well trained that this is the necessary step to make a decision. Administrators unfortunately have to make a decision on the basis of what they know and therein lies the difference in the perception of an agenda item which Ben referred to. The faculty think the item on the agenda is a problem definition; and the administrators think it is a matter to be disposed of. And if you have sufficient data, the two are the same thing: if you don't, they're not. And therein lies a real problem. I didn't mean to go back and change subjects but I believe — the differences between say Ohio State and Syracuse are what normally would be considered fairly fundamental — large public to medium large private, a different environment with a different set of programs — but I think some of the fundamental things that I think are important and were important here, like program budgeting and in a sense to get into program planning and analysis are fundamentally the same thing. I find no differences or at best little differences in the systems requirements. One big difference is that a private does tend to look at a thing called the marketplace and look for market share and look for where they can recruit and look for — you know, what their programs must be tailored to compete in a market against an infinitely less expensive public education system; whereas in a public institution like Ohio State the problem is closing the doors. That tends to be a different kind of problem. And the politics are of course fundamentally different. The legislative relations here, to make the grounds up versus the tops down case, isn't important. You can make the grounds up case in private education all you want; all you have to do is find the money to do it. So your relations with alumni and fund raising and in a sense with parents are much greater than they are say here. But I think that the systems, the fundamental underlying administrative systems and the structures are very little different and I think that speaks probably more favorably toward some of the things that Ben is trying to do than I might have said a year and a half ago. I would have argued there were more differences.

DR. LAWRENCE:

Nevertheless, I think that our experience has indicated that while institutions are more alike in terms of their management than they care to admit, the human problems involved are such that it's much better to go to the development of general purpose tools that can be used in various ways according to the personality of the administrator. One must make sure that these tools are capable of compatibility without being identical, tailored to the administrator and the institution to the extent that the institution is different. But for the most part, you're tailoring the tool to the artists that are using them, as opposed to tailoring the tools to the institution. Each president, vice-president, director, or whatever has his own personal style, and you're really handing him a paint brush and different kinds of colors. Some artists prefer one kind of brush and others prefer another type. And we've learned in the last two years that we're really not tailoring tools to an institution; we're tailoring them to the administration that's running the institution, hopefully even to the department chairmen who will be running the departments. Human characteristics become a lot more important than institutional characteristics.

DR. McKENNEY:

I would make a plea that you balance that "tailored" with an interesting concept that's been around since the fifteenth century called accounting principles. As we get into more comprehensive planning, if we're going to retain some systematic approach to the problem, there has to reside some residue that's understandable by a whole host of different people. Unless we make a strong effort, in addition to tailoring to specific models, to creating some standard, commonly accepted residue I think we're in trouble. I do think that is the power of the computer system. George Lombard, who is our Associate Dean for Planning and Faculty Organization, really is an organizational behaviorist who loves people and hates numbers. We can let him define issues in terms of faculty names. However right behind those names is a standard accounting T account to make sure that, after Mr. Lombard is ready we can run out what it is going to cost and the comptroller can look at it in his terms. I think that we are going to have to allow the individual freedom to choose his terms. Perhaps that is a luxury we are going to require in the university environment because we do have such complex interrelationships. On the other hand there is a great body of knowledge called accounting and it has worked in a lot of places for a lot of time and I don't think we should ignore its value.

DR. LAWRENCE:

Jim, I think you're correct here, and generally we are trying to put these two problems in two separate bags. We are talking about analytical tools or models or whatever you prefer as an illustration of the kind of thing that has to

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be tailored to the individual or the institution. On the other hand we talk about measures or a communications base, which is similar to a ruler. One of the things that we don't have in higher education is a common ruler that we can use to talk about the management problems in a quantitative sense across institutional lines. Interestingly enough, at first we thought that dealing with systems analysts and computer types would make the standardization of the measures a relatively simple task. Most analysts argue for standardization; they argue for systemitization; and they like taxomonies. But as we have gotten into the business of trying to identify measures necessary for management that can be used across the spectrum of management, we've discovered there's a greater difference of opinion among analysts among presidents. The analysts, the very supporters of measures, find themselves disagreeing rather violently about measures and all of the related aspects of a communications base in the area of management. Their differences are rather surprising to me because I had always perceived them as being at one in terms of how measurement should be done.

DR. McKENNEY:
As an example, I think the Purdue system, identifies the basic unit you're worrying about as cost per student credit. If you can relate and measure that, you're all right. Now, we may be naive, but it is that simple a notion that we are trying to develop a system for, for both planning and measuring the operating costs.

DR. LAWRENCE:
The National Center has also argued that this is a good unit, but we have a substantial number of people now raising their heads within the organization, particularly within our institutions, arguing that it is a very bad measure. And they're raising the issue very forcibly.

DR. McKENNEY:
But now measure for what? Cost per student credit hour is not a measure of performance. Costs are really a basis of data to imply where you want to go and what you want to do. They're not a measure of good or bad. It seems to me that what we are looking for are some simple exogenous measures of a phenomena that is going on and then some judgments and rationales for what you should do.

DR. LAWRENCE:
Unfortunately, I agree with you and the people who are arguing with us are not here. Their argument is that this kind of a measure will be used by people who have different values concerning the worth of the article that is being measured and that somehow measures are going to be misused by people who have differing values. They don't want that kind of a measure; they want the kind of a measure that will build in the value structure so that it will be hedged against. I don't know how you do the latter. I can see that if your public institution decides it is going to have a course in worms and decides to spend two hundred dollars a credit hour in educating somebody in worms, a legislator may come along and say, you know, I don't like worms. Consequently, you are not going to get funded. He doesn't say "I don't like worms." He attacks the cost and says it is inefficient to train people in worms. And those who are arguing with us don't want this kind of information out.

DR. McKENNEY:

Well, I think this may be a good point to end on. One of the challenges of planning is the one that Ron's raised and that Ben has just nailed down. When you make predictions and measures that are simple for you to understand and you are in a complex political situation, if you are the first guy to put his cards on the table, it can be very embarrassing. We all are in essence, it seems to me, *eleemosynary* organizations with a wide range of goals which serve the needs of society. I would hope that we would spend a lot of energy trying to understand those needs and selling those needs in the legislatures, and in our alumni councils. I hope we would not assume that if we are honest with what it is costing us to educate a Latin scholar we couldn't do it, so let's keep that cost shielded. I would prefer us to have a residue of faculty — or I should say, legislators — who understand the importance of worm study because it is really keeping the birds up there which are really stabilizing the ecology, rather than saying we can avoid that problem by submerging worm culture into a great surrogate called FTE per department. Thank you.

Chapter 4

Successful Computing Systems: Instruction, Research, and Administration

OVERVIEW

by Lawrence M. Stolurow
SUNY, Stonybrook

The objectives of this panel discussion were to present descriptions of successful approaches to the use of computers for instruction, in support of research, and for administration.

In dealing with this set of problems, two dedicated systems are described in terms of their capabilities, design and costs: a) a large system, PLATO IV, and b) a mini-system TICCIT.

PLATO IV, developed and described by Prof. Bitzer, University of Illinois, is designed to handle 4,000 terminals to service a radius of 150 miles around Champaign-Urbana, Illinois. It uses a 6,000 series CDC computer and a unique plasma display panel designed by Bitzer and Slattow for computer generated displays, plus newly designed random-access audio and visual computer-controlled display units. It is designed to handle 250 lessons at any one time, (PLATO III handles 35 now). The projected costs are 50 cents per student hour, or less, for delivery of the instruction to each student. Last year, over 20 courses for credit were taught on PLATO III. This involved between 40 and 50,000 student contact hours.

The TICCIT (Time-Shared Interactive Computer-Controlled Information Television) system is designed by MITRE Corporation. It was described by Prof. Wilson Judd, CAI Laboratory of the University of Texas. The design of TICCIT is for 128 terminals using off-the-shelf commercial hardware. The central processing will be accomplished by a Data General SUPERNOVA, with 32K of memory, as the main processor received and by standard peripherals. A smaller processor received and processes keyboard entries from the terminal and generates new displays. The system to be installed at the University of Texas, Austin, Texas is a redesign of a prototype previously developed by MITRE Corporation. The CAI Laboratory, under the direction of Dr. Victor Bunderson, is advising on the programming language which is designed to be like PL/I and they and Dr. R. David Merrill at Brigham Young University are developing courses for the system.

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Communications costs of both systems are being reduced below public utility standard by using CATV.

A successful development of a shared, rather than a dedicated, small computer is described by Michael Hall. The Beloit College experience had high student involvement in the development of courses and utilized an IBM 1130 with teletypes. A library (available on request at cost) produced over 100 programs at an estimated development cost of less than $15,000.

Rex Krueger, Director of the Computing Center, University of Colorado, describes his center and some of its many projects. He also showed a film of a computer simulation for highway design. Instruction is carried out in a shared environment and costs are allocated on a uniform basis. The center is operated "like a book store." It handled 350 courses last year and over 10,000 student hours.

The panel brings out several general points. A computing system can provide instructional support with state-of-the-art technology today and at rates that are cost competitive. Recent development such as the plasma display and the reductions in the cost of memory make the uses of computers for instruction more and more attractive and competitive. Use of computer-based instructional systems in what are currently high-cost areas of education is mentioned as a realistic way to begin. The development of new courses is a complex process involving deep analysis of the process of interaction, one which is more intensive than is traditional. Support personnel to assist in this are needed. Changes in the instructional process involving technology requires the organic integration of the computer-based instruction into academic programs. A fact-based, as contrasted with a fad-based, focus is a major contribution of computer-based instruction since it permits the interactive development of effective instruction and efficient evaluation of student progress. Both dedicated and time-shared systems that "piggyback" cost with basic uses can be successful in a university environment. Experience suggests that several options are viable approaches. One of the current needs is for better arrangements for the transfer of software. An inter-institutional mechanism is needed to promote distribution of programs, including translation, and to share common costs of research and development.

"SUCCESSFUL COMPUTING SYSTEMS: INSTRUCTION, RESEARCH, AND ADMINISTRATION"

by Lawrence M. Stolurow
SUNY, Stonybrook

I would like to begin the panel with a few points. First, I would like to indicate that our objective is to present descriptions of approaches to basic problems facing all academic institutions, namely, how to relate more effectively to the instructional process. In dealing with this problem, the panel will raise many questions about approaches. One of these is how institutions can be helped in their need to change in ways in which they do their primary job, teaching students.

I have identified ten problems in what I have seen of the papers and heard in the discussions I have had with the other panelists. Let me summarize them to focus your attention on some basic issues that will come up.

The first is: If instruction is a dynamic process of interaction and not just a problem of information storage and retrieval, the question we should ask is how do we increase the dynamic, or interactive, aspect given that the knowledge base is growing at an accelerated rate?

Two, if a change has to take place in the way in which academic institutions relate to the students' instructional needs given limited faculty resources, how do they plan to amplify these resources without a loss of effectiveness so as to produce change in an optimal way?

Three, if technological assistance is to be a part of the response to the need for more and improved instruction, it should be an integral component of a coherent system. How do we achieve this organic relationship between the new and the old?

Four, if instruction is to have a fact-based focus and not a fad-based focus, how do we get the needed facts and inform the faculty of them with minimal added expenditure?

Five, since the instructional process is such a complex phenomenon which has to be studied with both care and rigor, how do we provide an incisive means by which analysis and synthesis can be accomplished to provide interactive solutions to its problems?

Six, since the utilization of computer technology in and for instruction is really a family of different approaches, and not a single approach, how does an institution decide upon the one it should use?

Seven, since several successful models for beginning the use of computers for instruction have been demonstrated, how do institutions decide how they should get started?

Eight, since the transfer and propagation of successful means and patterns of use are more important than the replication of a demonstration designed more to convince the local doubters and critics of the validity of the approach, how are transfer and propagation best achieved in a viable operational way?

Nine, since many, if not most, of the basic problems in using computing systems for instruction are not systems design or hardware as much as they are pedagogical, psychological and sociological, how are these aspects to be dealt with? So that the academic institutions who want to benefit from computer technology are not delayed in their efforts to improve instruction, further development and not just the utilization of the existing knowledge base and scientific foundations is needed.

Ten, since there is a critical need for an effective mechanism to assist in the processes of course development, evaluation, selective adoption and use of computers for instruction, how is this need to be met so that the costs and expertise are distributed and shared by a number of institutions?

Obviously, a deep analysis of each of these problems is not possible by today's panel members in the time alloted. I point them out to alert you to them since the speakers will be touching upon them. Each of the ten problems will not be discussed by every participant; however, as a panel, we will relate to them in a way in which we hope to cast some light.

The last question, I think, is one which could very well provide a sequel to the kind of panel we have today and to which we might want to give further consideration.

We will follow the schedule of speakers as represented in your program on Page Six. Our first presentation is by Don Bitzer, who is director of the Computer-Based Educational Research Laboratory at the University of Illinois. It was overheard that Don thought of Plato's system as really a pretty hot ticket. The implications of that might come out in a later discussion.

THE DESIGN OF AN ECONOMICALLY VIABLE LARGE-SCALE COMPUTER-BASED EDUCATION SYSTEM

by Donald Bitzer
University of Illinois

The University of Illinois has been experimenting with a computer-based educational system (PLATO) for the past eight years. This system has evolved from a single terminal connected to the ILLIAC I (a medium speed, 1954 vintage computer) to a computer classroom of 20 graphic-pictorial terminals connected to a Control Data Corporation 1604 computer. Some of the areas in which studies have been conducted are electrical engineering, geometry, biology, nursing, library science, pharmacology, chemistry, algebra, math drill, computer programming, and foreign languages. This material has been presented by use of a variety of teaching strategies, ranging from drill and practice to student-directed inquiry. Based on these experiences and the data gathered over 70,000 student contact hours of credit teaching, this report describes the development of an economically viable teaching system. Some of our guidelines for developing the system's software and hardware are:

1. The computer should only be used when it is the best method of presentation. Less expensive methods such as programmed texts, films, slides, tape recorders, etc., should be used when appropriate.
2. The computer should be used as much as possible to simulate results in models constructed by the students rather than simply turning pages.
3. The system must be flexible and adaptable. It must be able to teach many subjects and present the lesson materials by a variety of teaching strategies. The system must change to meet the needs of the students and teachers, and not be limited to the off-the-shelf items presently available.
4. The method of integration into the educational system must be considered in the system design. For example, a school should be able to start with a single terminal for the incremental terminal cost instead of having to invest large sums of money for an entire system before the school has determined if it wants or needs C.B.E.
5. The cost of computer-based education should be comparable with the cost of teaching at the elementary grade school level. Cost effectiveness should be determined by an hour to hour cost comparison (25¢-30¢ per terminal hour for use of the computer and terminal).

A present student terminal consists of a keyset and a television monitor as shown in Figure 1. Information viewed on the television monitor is composed of a slide selected by the computer (random-access time less than 1 millionth of a second) and a superimposed image of graphs, diagrams, and/or alphanumeric characters drawn by the computer in a point-by-point fashion. The student uses the keyset for constructing answers, questions and for setting up simulated or real experiments as well as for controlling his progress through the lesson material. The computer responds to the student's requests within one tenth of a second.

The computer also controls other devices, such as movie projectors, lights, etc. The students at the terminals can interact with each other through the computer, thus permitting games to be played which require communication between the players.

In addition to keeping detailed records of the student's performance, the computer can provide individualized instruction, immediate feedback, and remedial training by the use of complex internal branching and the alteration of presentation or type of material based on the student's past performance. These unique features seem to make the computer an ideal instructional device for developing cognitive skills.

To encourage development of critical thinking skills, the author sets up the teaching strategy and presents the student with questions or problems so the student must think about what information he needs, about possible solutions to the problems or sources of information, interpret the data gathered, and test his solution. The computer immediately provides appropriate feedback to open-ended questions, thus reinforcing a correct approach, or in the case of an incorrect response, encouraging the student to a new approach.

The computational use of the computer appears in several ways. First, experiments can be simulated by the computer, immediately providing the student with results he uniquely requested. These same results might require hours or even days to calculate by hand. Second, a large amount of computation is involved in processing student responses. The more flexibility provided for the student to answer a question, the more feedback is needed to inform him of the correctness of his response. When only multiple-choice responses are required, the processing is relatively simple, but when the student is permitted to construct long alphanumeric and graphic responses the computer must analyze his answer to see if it is equivalent to a correct response, check for spelling and completeness of the answer, as well as inform him which part of an incorrect answer is unacceptable.

Whenever possible, algorithms are used to determine the correctness of the students' response. For example, when the student is asked to give a positive even integer, the student's answer is checked to see if it is positive and then it is divided by two and checked for a remainder. If there is no remainder, the answer is correct. The use of algorithms instead of comparing the answer against a long list of pre-stored answers not only makes the system more flexible but also saves memory space. In some cases this approach is almost a necessity. For instance, in teaching algebraic proofs, students can prove theorems in any manner as long as their statements follow logically from the available axioms and their previous statements. We have one example in which the author of the material was unable to prove a theorem in the twelve lines provided and, thus, was unable to supply even one pre-stored solution. Nonetheless, one student was able to complete the proof in the required twelve lines and was told by the computer he was correct.

To illustrate further how the computer interacts with the student we will describe some sequences taken from lessons in geometry, electrical engineering, and maternity nursing.

A user's computer language consisting of English directives was used to write a series of 15 lessons in informal geometry.* These lessons were to give 7th and 8th grade students an understanding of geometric concepts. A grid is

*This project was supported by the U.S. Office of Education under Contract OE-6-10-184, and by the National Science Foundation under NSF G-23554.

provided on which the student draws and manipulates geometric figures. The computer is used to determine the correctness of the figure, independent of its size, location, and orientation on the grid. The student must select points of the grid to be used as the vertices of his figure. To do this, eight keys on his keyset have been defined which move a bright spot around on the grid. (Figure 2 shows a diagram of these keys. The arrows on the keycaps indicate the direction in which the key jumps the bright spot on the grid). Once a student has decided on a point, he communicates his selection to the computer by pressing the "MARK" key. He presses the "CLOSE" key to close the figure (connect the first point to the last point). To judge the figure the student presses "NEXT" and the computer either okays the figure or indicates the student's error.

In the following sequence, the student is asked to draw quadrilaterals with a single line of symmetry. In Figure 3a the student is instructed to draw a quadrilateral with one line of symmetry: the two possibilities are an isosceles trapezoid and a kite. He selects the points he wishes to use for his figure and marks them. Figure 3b shows the partial construction of the trapezoid. When four points have been marked the student closes his figure and asks the computer to judge it. In Figure 3c the completed figure is judged and the computer points out to the student that the symmetry line for an isosceles trapezoid does not go through the vertices.

The student then moves to the next page of the lesson and is asked to draw a quadrilateral with a single line of symmetry that does go through the vertices (Figure 3d). The student, however, reconstructs the trapezoid. The computer, when judging the figure, recognizes the duplication and tells the student that he has drawn the same figure as he drew before (Figure 3e). The student then draws a kite which has a single line of symmetry through vertices and the figure is judged "OK" (Figure 3f).

For our second case we use a sequence taken from a circuit analysis course in electrical engineering (Figure 4). The student has just analyzed a circuit containing a battery, a switch, an inductor, and a resistor, all connected in series. His task is to determine the value of the inductor and resistor that causes the current waveform to pass through the points marked on the graph after the switch is closed. He is instructed to make the resistor value small and notice the effect on the final value of the current. By manipulating these values, the student gains an intuitive feeling for the effects of the inductance and resistance, and he can proceed in an orderly way to determine their correct values.

The third example is taken from a maternity nursing lesson* where the student is presented with a question which asks her to list two cardiovascular compensations which occur as a result of the increased blood volume during pregnancy (Figure 5).

The student, needing information to answer this question, presses the button on her keyset labeled "INVEST." She is then presented with a slide where she indicates that she wishes to investigate "Anatomic and Physiological Changes of Pregnancy."

After choosing her area of investigation, she is presented with a slide which requests further specification. Here the student indicates that she wishes information concerning changes which occur in the circulatory system during

*This project is supported by PHS Training Grant No. NPG 188, Division of Nursing, PHS, U.S. Department of Health, Education, and Welfare.

the third trimester of pregnancy. Having done this, she presses the "Answer" button and the computer generated information tells her there is an "increase in blood volume, a 50 percent increase in cardiac work load, left ventricular hypertrophy, and vasodilation produced by an increase in progesterone." Deciding that increased work load is one compensation, she considers left ventricular hypertrophy, but needs to further clarify the word hypertrophy. By pressing the button labeled DICTIONARY, she is presented with a list of terms used in the lesson. The student types the word "hypertrophy" and the computer supplies the definition "increase in size of an organ or structure."

By pressing the button labeled "AHA", the student is returned to the question on which she was working. Here she types the answer "hypertrophy of the left ventricle" and the computer judges it "OK." However, the answer "the left ventricle" is judged NC, that is, correct but not complete. Rewording the correct answer, the student types "the left ventricle enlarges" and the computer responds "OK." However, when the student presses the "CONTINUE" button to advance to the next page, the computer prints out "Duplicate Answer." Next, the response "the left ventricle decreases in size" is entered. The computer responds "NO" and XX's out the word "decreases." Before the student can continue, she must change one of her responses to a correct answer which differs from the first.

Records of each student's request (his identity, the key pushed, and the time to the nearest sixtieth of a second) is stored on magnetic tape. These data are processed by the same computer that is used for teaching. We have used these records for improving course content, designing better teaching strategies, as well as for planning new, economically viable computer-based education systems.

On the basis of CERL's experience with early PLATO systems, certain design philosophies for the proposed system have been formulated. First, each student terminal requires a keyset and a display, both connected to an inexpensive data transmission system which can also drive optional equipment such as random-access audio devices, reward mechanisms, movie films, lights, and so forth. Second, each student terminal must be capable of superimposing randomly-accessed color slide images on the computer-generated graphics. Third, the system should be controlled by a large-scale centrally-located computer rather than many small computers located at the classroom sites. This decision is based upon social and administrative factors as well as on system economics. Semiconductor large-scale integration techniques may some day make the use of small computers as effective as large ones, but the added human expense of operating a computer center does not promise to scale as effectively. It is our opinion that the initial low cost of a single terminal will permit tightly-budgeted public schools systems to economically incorporate computer-based teaching into their programs. The number of terminals could be increased or decreased as the needs of the school system dictate. Fourth, the cost per student contact hour for the proposed system must be comparable with equivalent costs of traditional teaching methods.

Before discussing an economical system design from the technical viewpoint, it is necessary to consider the cost of producing lesson material. Reported costs have ranged over a factor of 10 for producing similar lesson material. The differences in author languages can account

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for this wide range. The author language must be just as natural for the teacher to use as the teaching strategy is expected to be natural for the student to use. However, in the long run. The cost of lesson material should constitute only a small fraction of the educational cost just as the textbooks and lesson materials represent only a small part of educational costs today.

Preparing a good CAI course is roughly equivalent in effort to writing a good textbook. Most good authors are quite willing to produce textbooks at a 10-15% royalty rate which yields to them approximately 80¢ per student. Most textbooks are used in courses which have at least 40 hours of classroom instruction. The cost of royalties, reproduction and distribution of lesson material total to $1.20 per student and when used for 40 hours of instruction yields an eventual cost of approximately 3¢ per student hour of instruction. The reproduction and distribution of materials for computer-assisted instruction terminals promises to be very inexpensive (approximately 40¢ per student for visual and audio materials).

Statistical records of over 70 million requests on PLATO indicate that the average request rate per student depends upon the teaching strategy used, but the product of the average request rate and the average processing time is relatively constant. For example, when using a drill-type teaching strategy the average request rate per student is one request every 2 seconds and the average processing is 10 milliseconds. When using a tutorial or inquiry strategy, the average request rate per student is one request every 4 seconds but the processing time is 20 milliseconds. We will base our calculations on the 20 millisecond processing time which is equivalent to executing approximately 1000 instructions in the CDC 1604.

The request rate probability density function versus computer execution time is approximately an exponential curve; therefore, student requests requiring the least amount of computer time occur most frequently. For example, the simple and rapidly-processed task of storing a student's keypush in the computer and writing the character on his screen represents 70 percent of the requests. On the other hand, the lengthy process of judging a student's completed answer for correctness, completeness, spelling, etc., occurs only 7 percent of the time.

Several existing large-scale computers can perform about $4x10^6$ instructions per second. Even if we double the number of instructions needed, providing 2000 per student request, it is seen that these large-scale computers require an average processing time of only 500 microseconds per request. Allowing a safety factor of two to insure excellent system response time, the system can accept an average of 1000 requests per second. This safety factor implies that the computer will be idle approximately 50 percent of the time. However, the computer time not utilized in processing the student requests can be effectively used for other purposes such as background batch processing. Since the average student request rate is ¼ of a request per second, the system can handle up to 4000 students simultaneously, allowing one millisecond to process a request.

Assume that the student input arrival time is Poisson distributed (a reasonable assumption for 4000 independent student stations), and that the request rate probability density function versus computer execution time is approximately exponential (PLATO statistical records substantiate this).

From queuing theory [2,7] the expected waiting time E(w) that elapses before the computer (single channel) will accept a given student's request is given by

$$E(w) = \frac{\rho^2 + m^2 \sigma_t^2}{2m(1-\rho)} \qquad (1)$$

where

m = request rate = 1,000 request/sec.,

σ_t = execution time standard deviation = 500×10^{-6} sec.,

$E(t)$ = execution time expected value = 500×10^{-6} sec.,

ρ = $m\,E(T)$ = 0.5

These values yield an expected waiting time E(w) of 500 microseconds. The probability P(w) that a student's request will wait a time w or longer before being served by the computer is given by

$$P(w) = \rho \ \exp\,[-w\,(1-\rho)/E(T)] \qquad (2)$$

The probability that a student must wait for a 0.1 second or longer is negligible. Hence the probability of a student's request queue becoming long, or of the student experiencing a noticeable delay is very small.

Presently, each student needs to be assigned approximately 300 words of extended core memory to be treated individually. The maximum used in any teaching strategy has been 600 words per student. Let us allow on the average 500 words (fifty bit) for each student for a total of 2×10^6 words for 4000 student terminals. Our data shows that 20 percent of the computer instructions refer to these words of unique student storage. Therefore, the system must be capable of rapidly transferring data between the slower extended core storage and the high-speed core memory. Some existing computers are capable of transferring data at 10^7 words per second, requiring only 50 microseconds to transfer the data each way between the memory units. This transfer time is acceptable.

The peak data rate from the computer to each student station is limited to 1200 bits per second to permit data transmission over low-grade telephone circuits, a system feature made possible by the use of the plasma display panel discussed later. For 4000 stations the worst case data rate would be about 4.8 million bits per second, well within the present state of the art for buffering data out of a computer.

Summarizing the computer requirements, therefore, the central computer requires about 2 million words of extended core memory capable of high-speed transfer rates to the main computer memory, it must have an execution time of approximately 4 instructions per microsecond and be capable of transmitting data at a rate of 4.8 million bits per second. There should be a sufficiently large memory (64k to 128k words) in the central processing unit for storing lessons (1k to 2k words per lesson) and for the various teaching strategies. Several existing computers meet these requirements.

The economic feasibility of the proposed teaching system is dependent upon the newly-invented plasma display panel (or equivalent device) now under development at the University of Illinois and other laboratories. This device combines the properties of memory, display and high brightness in a simple structure of potentially inexpensive fabrication. In contrast to the commonly-used cathode ray tube display, on which images must be continually regenerated, the plasma display retains its own images and responds directly to the digital signals from the computer. This feature will reduce considerably the cost of communication distribution lines. The plasma display is discussed in detail in the listed references. Briefly, it consists of a thin glass panel structure containing a rectangular array of small gas cells (about .015 inches density of about 40 cells per inch — see Figure 6). Any cell can be selectively ignited (gas discharge turned on or turned off by proper application of voltages to the orthogonal grid structures without influencing the state of the remaining cells). A small, developmental panel displays two characters. Each of these characters is only one-eighth inch in height. The plasma panel is transparent, allowing the superposition of optically projected images.

A schematic of a proposed student terminal using the plasma display is shown in Figure 7. The display will be approximately 12 inches square and will contain 512 digitally addressable positions along each axis. A slide selector and projector will allow prestored (static) information to be projected on the rear of the glass panel display. This permits the stored information to be superimposed on the panel which contains the computer-generated (dynamic) information. A prototype random-access slide selector for individual use is shown in Figure 8. This projector is digitally addressable, pneumatically driven, and contains a matrix of 256 images on an easily removeable four-inch square plate of film. The film plate is mounted on a Cartesian-coordinate slide mechanism and can be simultaneously translated along either of the two coordinate axes to bring a desired image over a projector lens. The positions along each coordinate axis are selected by a set of four pneumatic cylinders mounted in series. The stroke length of each cylinder is weighted 8,4,2,1, the length of the smallest being ¼ inch. Each slide selection requires less than three cubic inches of air at 8 psi. Based upon the prototype model now being tested, a low-cost image selector with approximately 0.2 second random-access time is anticipated.

Data arriving from the computer via a telephone line enters the terminal through an input register. As previously stated, data rates to the terminal will be held to 1200 bits per second. Assuming a word length of 20 bits, the terminal could receive data at 60 words per second, an important design feature when considering standard TV tariff for communicating. With proper data formats, data rates will be adequate for the applications envisaged. For example, packing three character codes per word will permit a writing rate of 180 characters per second, which is a much faster rate than that of a good reader. Using 18 bits to specify a random point on the 512x512 array, 60 random points per second can be plotted. If the x increment is assumed such as when drawing graphs, 120 graph points per second can be plotted. In addition, continuous curves requiring only 3 bits to specify the next point can be drawn at rates of 360 points per second. The keyset will provide the student with a means of communicating with the computer. The problem of converting the fast parallel output data from the computer into serial data for transmission to terminals at 1200 bits/sec. has been studied. This can be solved by the use of small size buffer computers performing the parallel-to-serial data conversion.

In the situation where a large number of students are located at considerable distances from the central computer, costs can be lowered drastically by use of a coaxial line instead of numerous phone lines. For example, the cost of a 4.5 MHz TV channel is approximately $35 per month per mile, whereas the rate for a 3kc telephone line is approximately $3.50 per month per mile. Each TV channel can handle at least 1500 terminals on a time-shared basis, each terminal receiving 1200 bits per second. Hence, for an increase in line cost of a factor of 10 over that of a single channel, an increase of a factor of 1500 in channel capacity can be obtained. In addition to a coaxial line transmitting 1500 channels at 1200 bits per second from the computer to the terminals, a data line for transmitting the student keyset information back to the main computer center is required. A data channel of 100,000 bits/second capacity, available from Bell Telephone can handle 1500 students, allowing 60 bits/second to each student. The costs for this line are approximately $15 per month per mile. Data to remote locations will be transmitted by a coaxial line to a central point; from this point local telephone lines rented on a subscriber's service basis would transmit the proper channel to each student terminal. A block diagram of a proposed distribution system to several remote points is shown in Figure 9.

Over 200 cities, and on a more limited scale many schools, already use community antenna television systems or closed-circuit TV. Because FM radio had already established itself prior to the spread of television, a frequency gap existed between channels 5 and 6 which is almost 8 channels wide. These existing channels can be used to communicate to over 12,000 home terminals.

The mainframe cost of a computer meeting the specified requirements is approximately 2.5 million dollars. The additional cost for two million words of memory and other input-output equipment is approximately 2 million dollars. An estimate for the system software, including some course development programming, is another 1.5 million dollars. The total of 6 million dollars amortized over the generally-accepted period of 5 years yields 1.2 million dollars per year.

Assuming that the 4000-terminal system will be in use 8 hours a day for 300 days a year, there are approximately 10 million student contact hours per year. The system costs, excluding the terminals, is thus 12¢ per student contact hour. In order for the equipment cost to be comparable to a conventional elementary school classroom cost of approximately 27¢ per student contact hour, the terminal costs must be limited to 15¢ per student contact hour, or to a total cost of about 7.5 million dollars over a 5 year period. The cost for each of the 4,000 terminals, which included a digitally-addressed graphical display device and its driver, a keyset, and a slide selector must therefore be a maximum of approximately $1900. Present indications are that this cost can be met.

Data distribution costs for a CBE center approximately 100 miles from the main computer are approximated as follows. The coaxial line rental is approximately $3500 per month, or $2.35 per terminal per month, based on 1,500 terminals. The 100,000 bit/second wide-band data channel line is approximately $1500 per month, or $1.00 per terminal per month. Allowing $3.00 per terminal per month for a private telephone line from the coaxial terminals to each student terminal gives a total data distribution cost of $6.35 per terminal per month, or 4¢ per student contact hour if each terminal is used 160 hours per month. The author costs were discussed previously.

These costs, based on the above assumptions, are summarized in Table I.

The earning power of the computer for the remaining 16 hours each day and for the idle time between student requests, which would further reduce costs, has not been included.

Conclusion

Using newly-developed technological devices it is economically and technically feasible to develop large-scale computer-controlled teaching systems for handling 4,000 teaching stations which are comparable with the cost of teaching in elementary schools. The teaching versatility of a large-scale computer is nearly limitless. Even while simultaneously teaching 4,000 students, the computer can take advantage of the 50 percent idle time to perform data processing at half its normal speed. In addition, 16 hours per day of computer time is available for normal computer use. The approximate computer cost of 12¢ per student contact hour pays completely for the computer even though it utilizes only 1/6 of its computational capacity. The remaining 5/6 of its capacity is available at no cost.

Table 1

SUMMARY OF COSTS

Item	Total Cost in millions of dollars	Cost/year in millions of dollars 5 years Amortization	Cost per student contact hour
Computer and extended memory	4.5	0.9	8¢
Software	1.5	0.3	4¢
4000 student terminals	7.5	1.5	15¢
Subtotal	13.5	2.7	27¢
Lesson material	—	—	3¢
Data distribution lines	—	—	4¢
TOTAL			34¢

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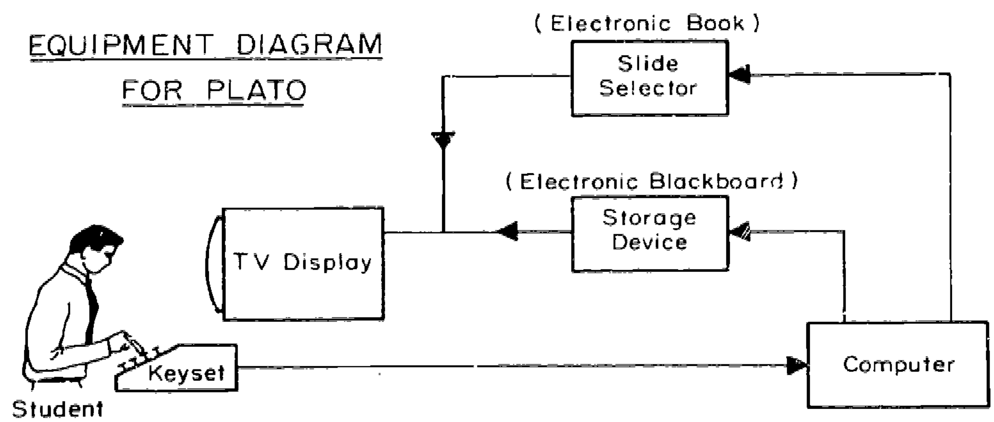

Figure 1

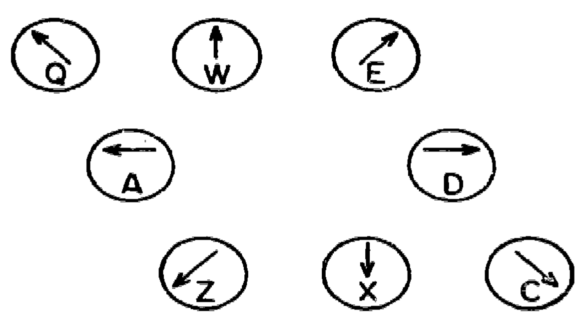

Figure 2

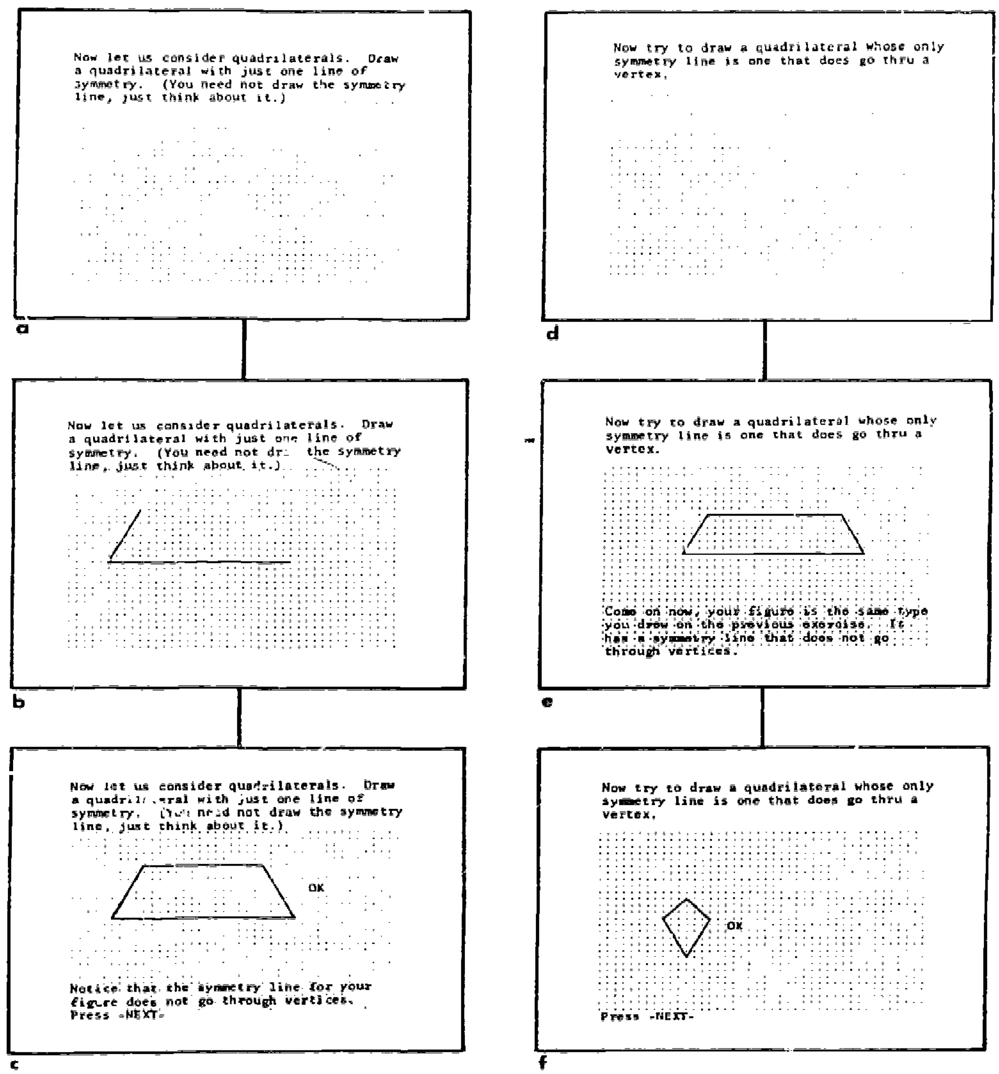

Fig. 2 An Example From a Geometry Lesson

Figure 3

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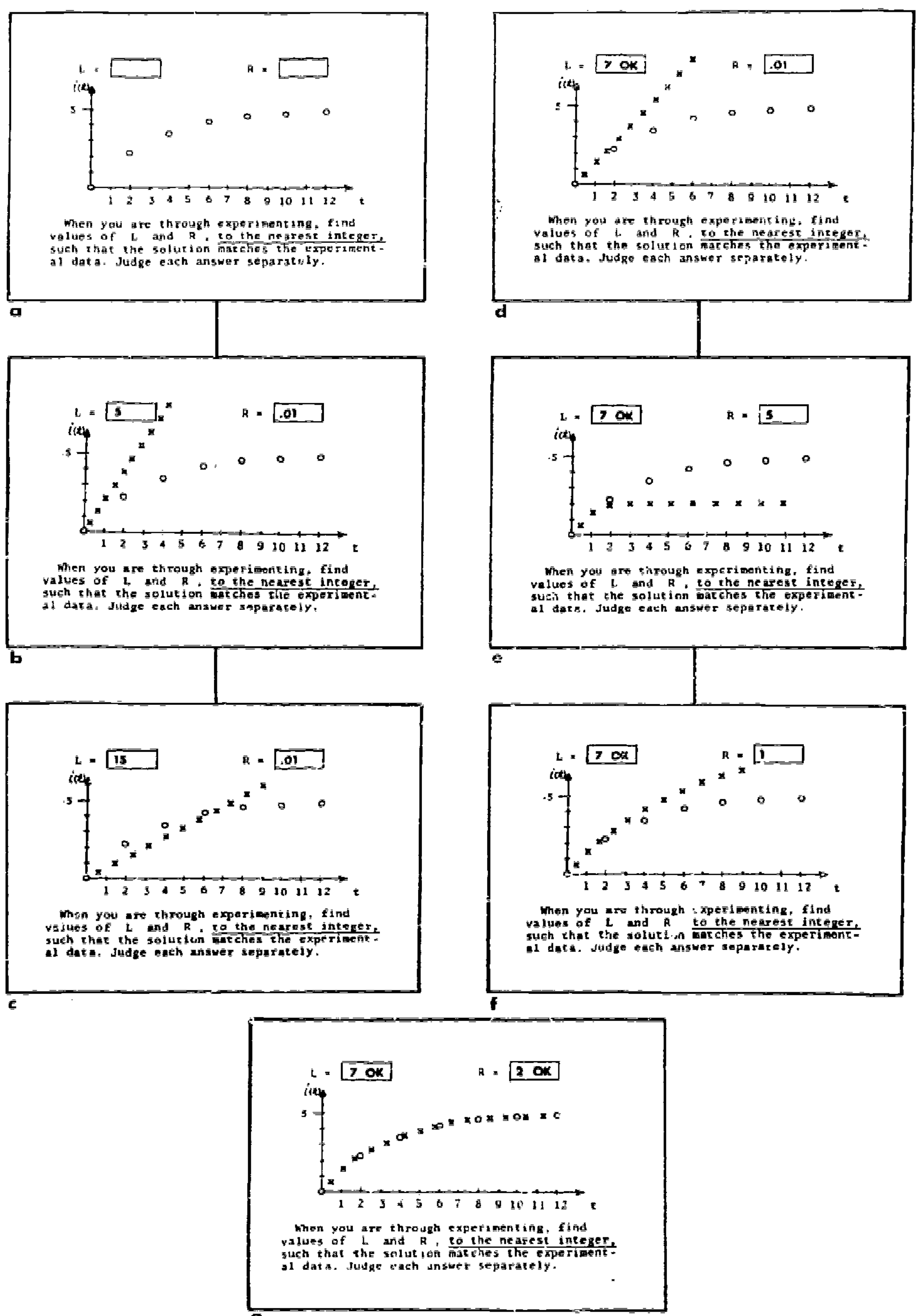
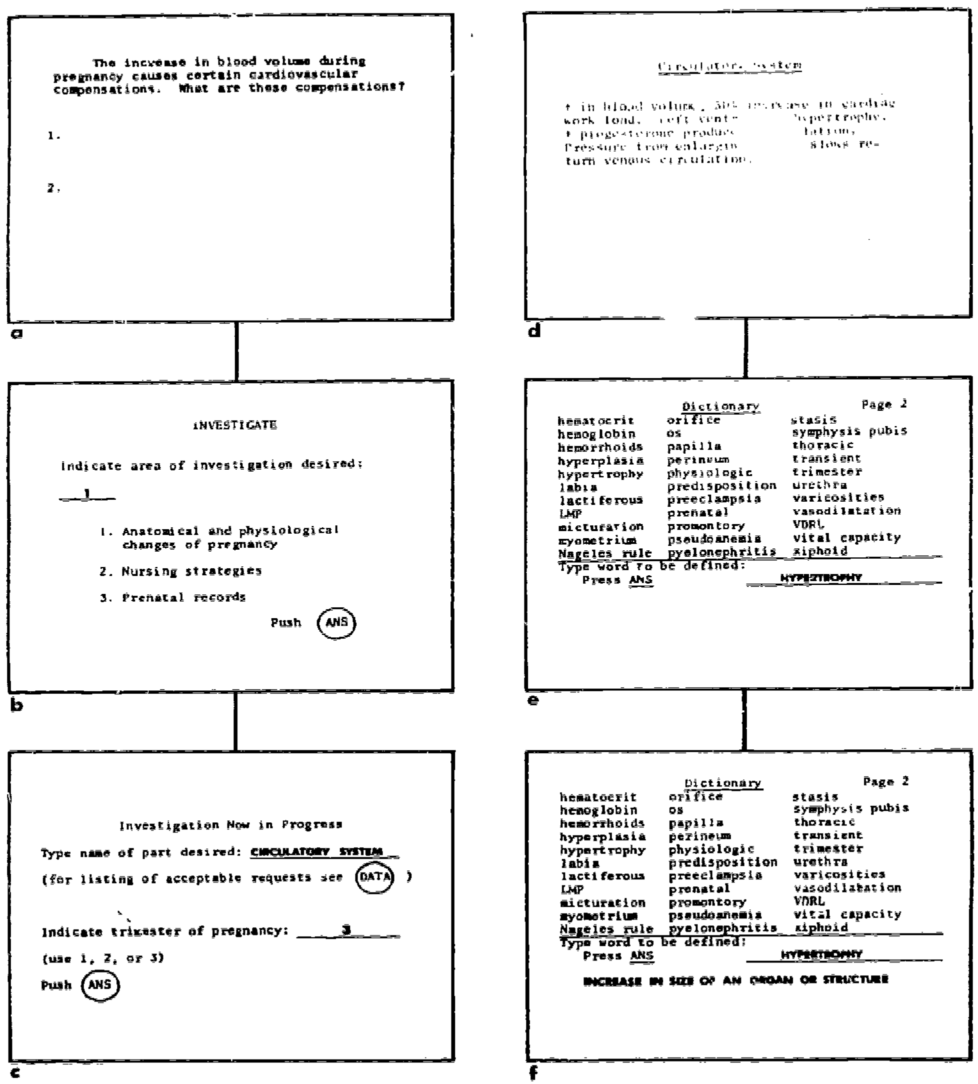

L =
R =
When you are through experimenting, find values of L and R, to the nearest integer, such that the solution matches the experimental data. Judge each answer separately.
a
L = 5
R = .01
b
L = 15
R = .01
c
L = 7 OK
R = .01
d
L = 7 OK
R = 5
e
L = 7 OK
R = 1
f
L = 7 OK
R = 2 OK
g

Figure 4



The increase in blood volume during pregnancy causes certain cardiovascular compensations. What are these compensations?
1.
2.
a
INVESTIGATE
Indicate area of investigation desired:
1
1. Anatomical and physiological changes of pregnancy
2. Nursing strategies
3. Prenatal records
Push ANS
b
Investigation Now in Progress
Type name of part desired: CIRCULATORY SYSTEM
(for listing of acceptable requests see DATA)
Indicate trimester of pregnancy: 3
(use 1, 2, or 3)
Push ANS
c
work load.
turn venous circulation.
d
Dictionary
Page 2
hematocrit orifice stasis
hemoglobin os symphysis pubis
hemorrhoids papilla thoracic
hyperplasia perineum transient
hypertrophy physiologic trimester
labia predisposition urethra
lactiferous preeclampsia varicosities
LMP prenatal vasodilatation
micturation promontory VDRL
myometrium pseudoanemia vital capacity
Nageles rule pyelonephritis xiphoid
Type word to be defined:
Press ANS
HYPERTROPHY
e
Dictionary
Page 2
hematocrit orifice stasis
hemoglobin os symphysis pubis
hemorrhoids papilla thoracic
hyperplasia perineum transient
hypertrophy physiologic trimester
labia predisposition urethra
lactiferous preeclampsia varicosities
LMP prenatal vasodilatation
micturation promontory VDRL
myometrium pseudoanemia vital capacity
Nageles rule pyelonephritis xiphoid
Type word to be defined:
Press ANS
HYPERTROPHY
INCREASE IN SIZE OF AN ORGAN OR STRUCTURE
f

Figure 5

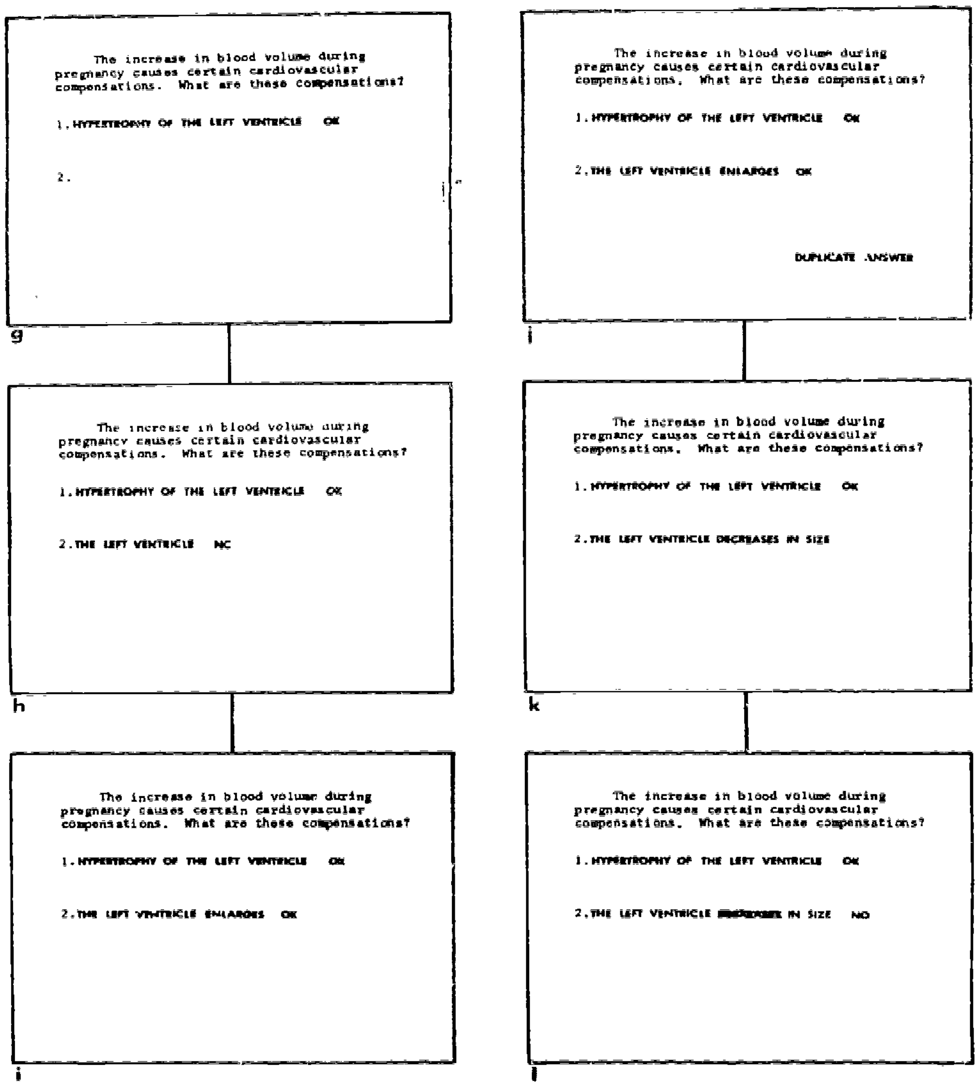


Figure 5 (Cont'd)

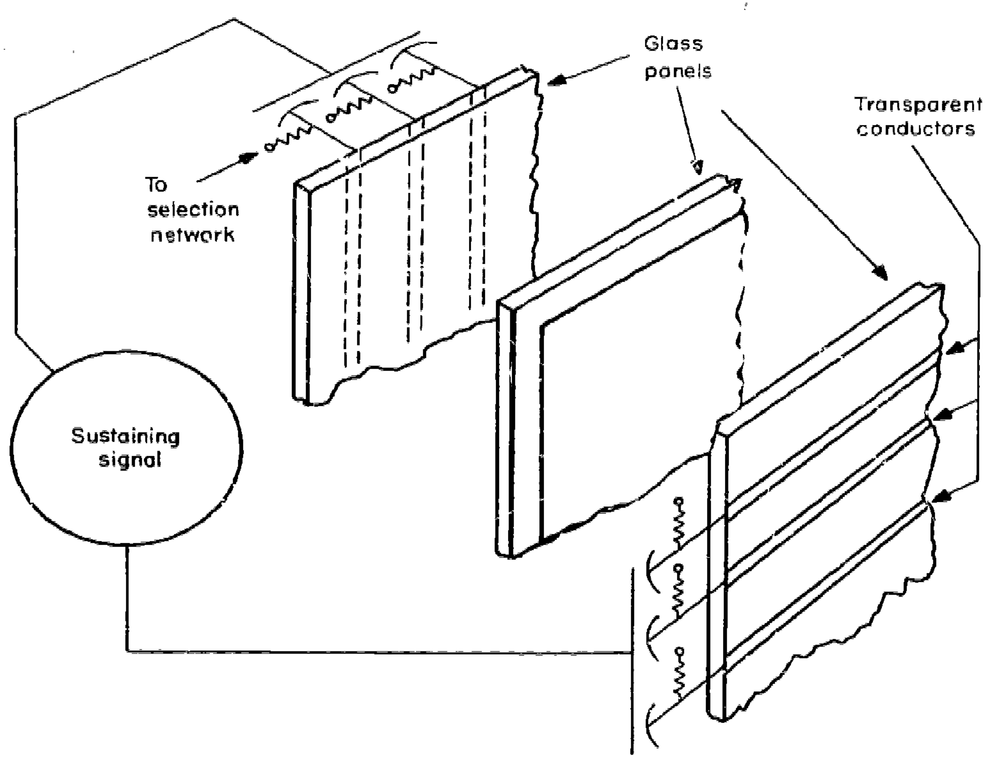


Figure 6

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STUDENT TERMINAL

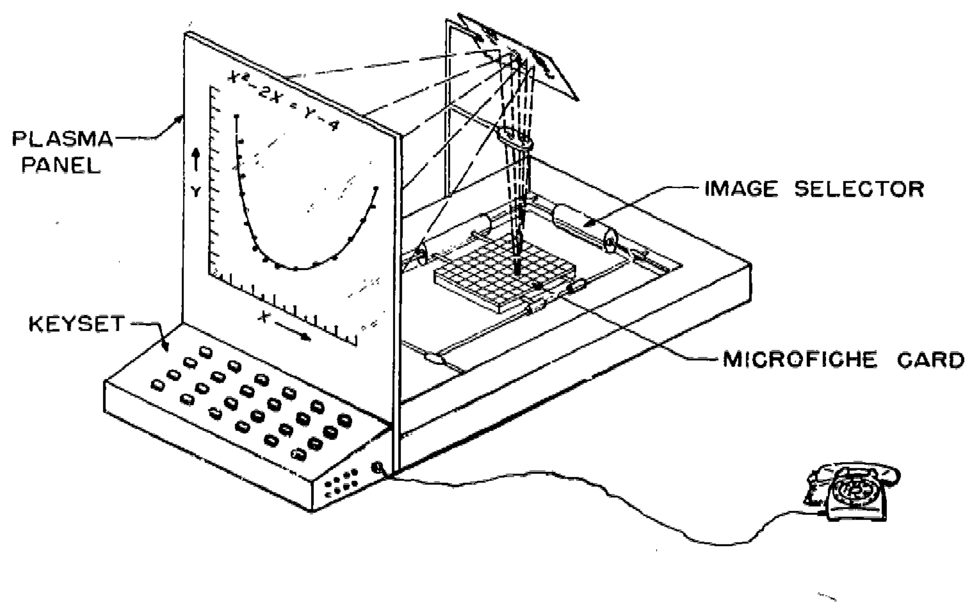

Figure 7

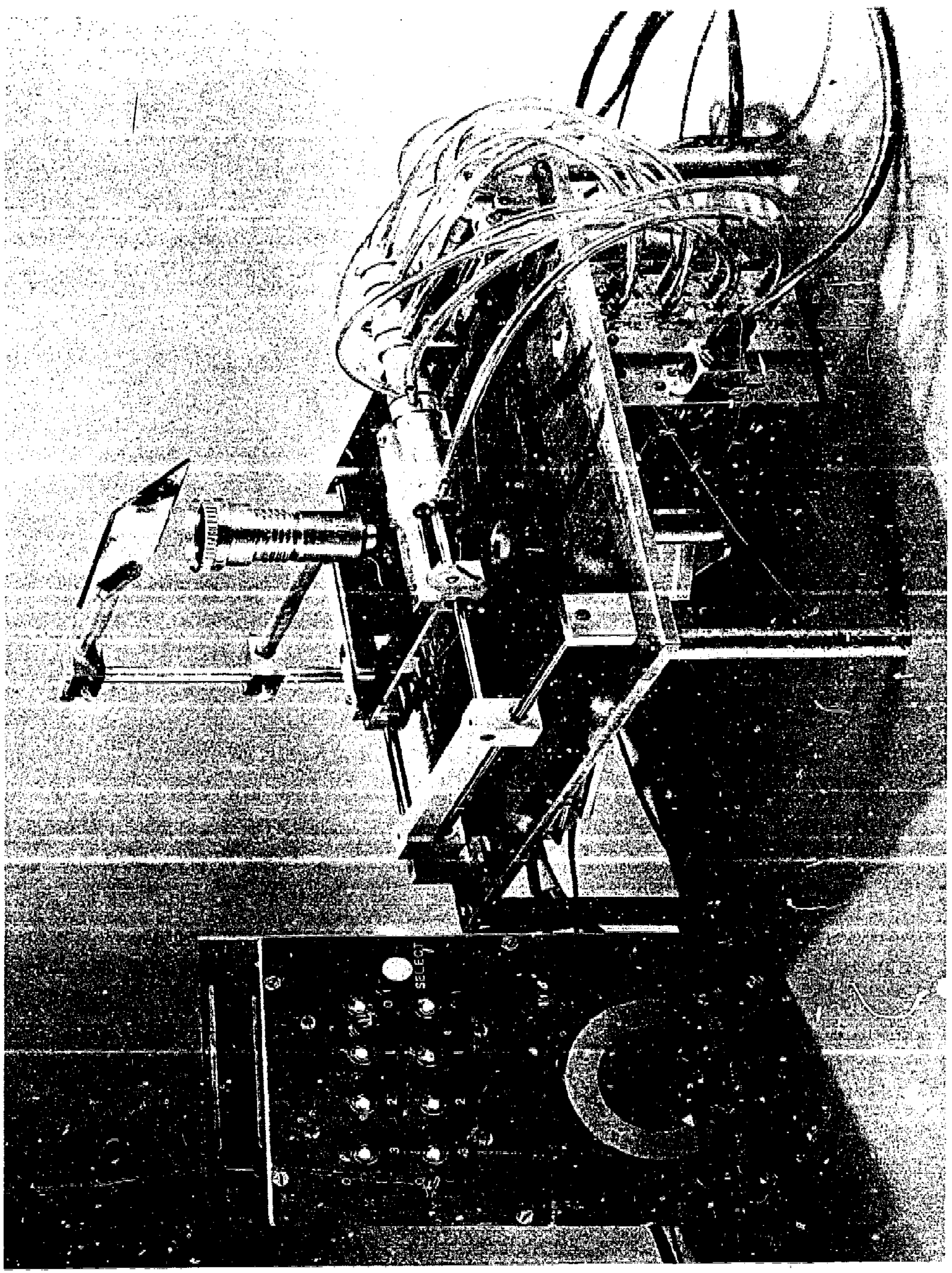

Figure 8

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Full Text Provided by ERIC

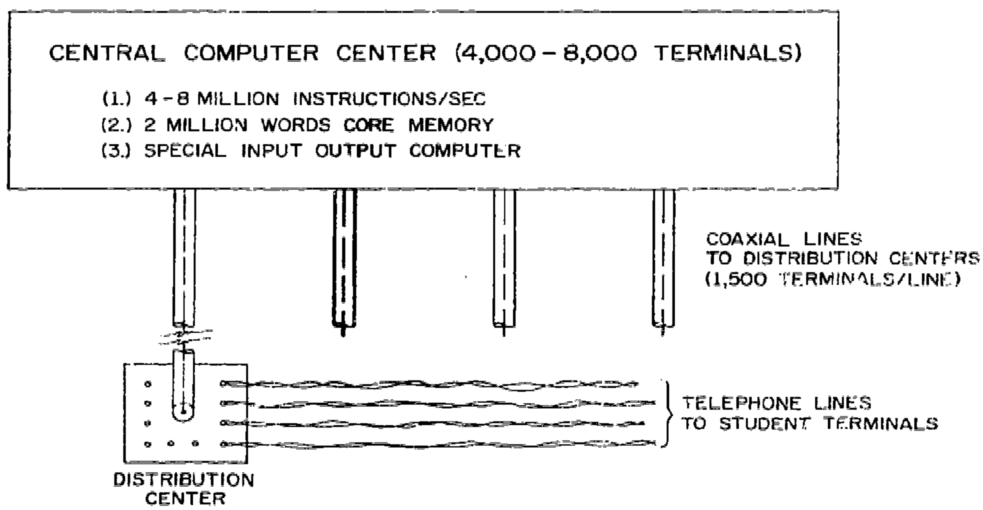
CENTRAL COMPUTER CENTER (4,000 – 8,000 TERMINALS)
(1.) 4 – 8 MILLION INSTRUCTIONS/SEC
(2.) 2 MILLION WORDS CORE MEMORY
(3.) SPECIAL INPUT OUTPUT COMPUTER
COAXIAL LINES
TO DISTRIBUTION CENTERS
(1,500 TERMINALS/LINE)
TELEPHONE LINES
TO STUDENT TERMINALS
DISTRIBUTION
CENTER

Figure 9

MEETING THE NEED FOR A BETTER FRONT END

by Michael A. Hall
AUERBACH Associates, Inc.

Since portions of the work on which I will be commenting today were done under a federal grant, since I am now a Consultant with AUERBACH Associates, which is currently performing work under contract to the Federal government in several areas, and since I will be rude to a number of you without knowing who you are, I will try to escape all repercussions by saying that portions of the systems and software development activities reported herein were supported by National Science Foundation COSIP Grant No. GY-4700 and by Beloit College. The opinions expressed are those of the author, however, and are not necessarily those of the National Science Foundation, Beloit College, or AUERBACH Associates, Inc. Furthermore, and this is quite important, nothing that I say should be interpreted as an endorsement on the part of myself or AUERBACH of the products or the services of the manufacturers of the hardware which I will be mentioning — nor of the agents or subsidiaries of such manufacturers.

In particular, I am going to be talking about a system for an IBM 1130, and frankly I don't think the 1130 is a great computer. But there are lots of them around and I know an awful lot of college administrators who think they're just dandy. I'd rather see them buy a number of other things, including things like PDP's, but they are not buying them. So, I'm going to be talking about 1130's.

Even though I'm going to be talking about an 1130 based system or a model system based on 1130's, I want to say that I think the area that Pete Lykos talked about this morning really looks great and I look forward to Pete or Don Bitzer or anybody — join the gang — making the sort of thing I'm talking about absolutely technologically obsolete. I think it's great, because I'm really talking about a system which is very much a compromise. On the other hand, what I'm talking about could be on your campus in a matter of weeks, since it's all based on existing hardware and proven systems. The choice you make depends on your priorities.

Re Bob Taylor's remarks this morning, I would like to publicly second his observation by saying that I have found that undergraduate students are the *only* reliable, low-cost, high-output resource in educational computing. I used to say *all* students, until John Lubin at Penn had me over to talk to one of his classes; he pointed out to me that *his* students in the Wharton School of Finance had become aware of their market value and are thus no longer low cost. The students who wrote the programs at Beloit were paid somewhere between a dollar fifty and three dollars an hour. You can check with John on what the going price for a Wharton Masters' candidate is these days.

One other point, and I want to say this particularly because of the Texas lab presentation that preceded me. I will probably succeed in offending some people today; if you thought that Barry Wessler was irreverent this morning, you haven't heard anything yet. (By the way, Barry, you should know, if you don't already, that the gentleman who raised the question with you was E.P. Miles, whom I and lots of others are very sorry to see leaving the chairmanship of SIGUCC and the Directorship of the Center at Florida State. He has for so many years provided the leadership for those of us who believe in the computer as an educational resource on campus, with full availability.) I will say some things that may seem to some of you a little extreme. When I was in college I worked for a while in a youth center. The guy I reported to was a trained social worker, and I would come into his office after being out with these hoodlums for the evening and start telling him about what a bunch of schnooks they were. And he would point to the sign that was above his desk. The sign read, "Through conflict comes growth." And I hated the guy for that; I thought that was a really snide thing to say. But he's right. Unfortunately, I'm probably the only member of this panel who won't be here tomorrow; I have to go to Atlanta tonight. I would have had to go to Atlanta if I hadn't been speaking; I'm not running away from you; I'm regularly in Philadelphia, and you can get at me there for more conflict and growth.

I'll be referring to a library of software which was developed at Beloit College. That library, either some or all of those programs, has already been distributed to over two hundred colleges and universities. On one of the view graphs I'll be showing there is an indication that you can obtain tapes of and documentation for that library from Beloit. That service has in fact been suspended since this last summer, due to financial problems at Beloit. I hope that we can make some arrangements within the next few weeks to keep that library available at a reasonable cost.* I must say, to say the first directly rude thing, that the total personnel cost to develop the program library which you will see displayed on the screen as Exhibit 2 was less than the cost of developing the Arabic course which was cited by the preceding speaker.

Most colleges now consist of administrators and faculty and students and a computer. I believe most colleges have been using their computer in the traditional capital intensive manner, to automate routine work such as payrolls and student records; to systematically quantify some of their subjective decisions, such as admissions and financial aid; to support research by faculty members and graduate students; and to automate introductory courses, usually in calculus, physics, accounting or foreign languages, which have traditionally been taught in a highly structured fashion for one reason or another, in order to reduce or eliminate the professional manpower requirements of, for example, the typical introductory one-term course in physics for non-physics majors. I'm not opposed to that automation because it replaces instructors by machines, by the way. It's been my experience that the quality of instruction in those courses has been so abysmally low for so many years that almost any change would be an improvement. What I'm really concerned about is that the automation can consist of putting onto the machine the same subject matter and pedagogical approach that's been turning the kids off for years; I don't think that is the right approach.

A few colleges have been using their computer, combined with relatively small amounts of capital and very large quantities of student labor, to make major improvements, I think, in the traditional pedagogy of undergraduate instruction, and in some disciplines these improvements in pedagogy have been so great as to really change the nature of the disciplines themselves. And I think some of the PLATO programs for example, have helped to do that.

*As of December 1, 1971, the library is again available. The prcedures for obtaining further information about it, and copies of all or parts of it, is given at the top of Exhibit 2.

All of this activity has cost a great deal of money, and only a very small percentage of the total amount spent on computing in higher education has been applied to innovative instructional systems. I think there are some quite clear reasons for the lack of emphasis on computers in instruction.

First of all, as far as how the college spends its money, the college generally wants its administrative computing done first. Administrative computing gets first priority on many campuses, particularly at the small and medium-sized colleges where there's only one computer available. Many computer center directors report to the college's financial officer and not to the dean of the faculty or the dean of academic affairs, and, certainly on most campuses, he does not report to some sort of board, such as the board at Dartmouth, which represents student and faculty interests. The problem with administrative computing, in my view, is that when a campus tends to focus most of its efforts on getting the administrative computing going, there's a tendency to just take the standard clerical procedures you've been using and put them on the machine. In other words, aside from a few innovative approaches taken to administrative computing (such as those of WICHE and SRG in Toronto, to mention a couple), most administrative software systems that I'm acquainted with are straight EDP interpretations of previously established clerical procedures.[1] They don't require innovative systems or applications programming nor do they generate innovative systems and applications programming. And quite frankly, and I think this will be recognized by Ben Lawrence, the relevance of even the WICHE type of system to the most important needs of the smaller and medium-sized colleges and even some of the most important needs of the large institutions hasn't really been tested yet.

The second barrier to computers in instruction is that faculty and graduate students are the big users at most college and certainly most university computing facilities. They are usually known to (and *sometimes* respected by) the computer center staff; they tend to ask what appear to be intelligent questions and they tend to want to make what appears to be efficient use of the computer. And of course, their research grants help to pay the costs of computer center operation, not the least of which is job security for the computer center staff. Thus, they tend to get a large share of that always scarce resource, advisory time of the center personnel. And their needs and their desires tend to be taken into account in obtaining and developing and changing systems.

Third, instructional computing has been and continues to be (and will be, until Don Bitzer and others save us from ourselves), a very expensive activity, in terms of both hardware and CPU cost and software development costs. At present cost levels of two dollars to seven dollars per student terminal hour on most time-sharing systems, colleges should wonder, as Braun has done with respect to high schools, "What would happen to the learning experience of our children if we paid their teachers two dollars to seven dollars per student contact hour, or reduce class sizes so that the per pupil costs were equal in the two modes of instruction."[2] I don't know the answer to that, but I'll try to justify using the computer anyway because I like making a living in this business.

In addition to these general constraints on instructional computing, which I think arise from the way in which computing has grown and the way in which it's administered and the way in which the technology is structured these days, I think there are three more constraints on instructional computing that can be ascribed more to the way in which instructional computing itself has grown.

First of all, until quite recently a large fraction of such funds as have been available for instructional computing have been consumed in support of intensive development efforts on hardware and software systems of considerable complexity, usually based on a single dedicated central processor. Most of the software that is developed in these efforts is not readily transferable to another installation nor was it ever intended to be. The research has been by way of an experiment, to see, for example, whether a kid can learn faster with CAI of some sort than he can learn in conventional instruction. It's sometimes hard for me, and maybe that's just because I'm a trained statistician, to figure out in some of these articles just what that conventional instruction really was and how I would transfer that knowledge someplace else, but that may be just my problem. The thing that is of interest to me is that I note a general finding in most such studies, namely the kids seem to learn better with a computer, somehow defined — and I'm not questioning the honesty of the people; I think they really do find that the guy learns better in some meaningful way — but at a much higher cost. Now, my problem is that these conclusions apparently strike some people as very original and important research results. I think they should have been obvious to anyone who is aware of the generally mediocre quality of instruction in higher education, not to mention lower education, and aware of the cost structures which affect computing of any kind. I just wonder what we have learned from these experiments; they have sure cost a lot of money.

Second, most instructors and students who would have the most to contribute to and to gain from instructional computing and from instructional software development have had at best very little incentive to make use of the facilities, whatever they happen to be, that were available on their campuses. Very few computer centers have on their own initiative begun and encouraged the development of even modest forms of instructional software, be it CAI or service or augmentation or what have you. Center personnel are often only minimally interested in even assisting instructional applications, particularly when they learn the truth, which is how very naive and inefficient, in systems terms, some of these users are. Another problem has been, of course, that you can't give these people a discount — you know, we'll get rid of those characters; we'll make them compute at three o'clock in the morning. And to get them to compute at three in the morning, we'll sell them time cheap. That hasn't been an open option in most centers because of legislative and legal problems. This is unfortunate, because our experience at Beloit was that a lot of good work got done at 3 a.m.

And last but not least, I'll have to say that the most university computer centers — and I don't mean all, but most — are very unreliable in their service patterns, a factor which is of *great* importance in instructional computing, both because of the nature of the work that the software user, i.e., the student at the terminal, is doing and because of the relative inexperience and sort of gun-shyness of both the user and of the faculty sponsor, the guy who has gotten the money to write the little software package. It is to me very unfortunate that the only way to get better service for instruction seems to be — at least this was what was being said at the SJCC last spring — to convert to real money transactions. Everybody gets real money and gets to spend it wherever they want to. I think that is too bad, even though I was once a student of the Chicago school of economics, because I think it will threaten very valuable aspects of

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present computer center operation which will not be able to stand the real money test. But it will at least give people who've got some money to do some instructional computing decent value for their dollar, which in general they haven't been getting under present funding systems.

By the way, I should say that I made a similar broad indictment of university computer centers at ACM 70 last fall and in that indictment I specifically exempted Dartmouth College, which I thought had been doing a bang-up job. And Tom Kurtz told me afterwards that by his standards, Dartmouth had not earned that exemption: The Dartmouth service was pretty lousy compared to what it should be. Well, if Tom Kurtz thinks Dartmouth service is pretty lousy, we're all in trouble.

Finally, adapting other people's software can save time and money in instructional computing. It can permit comparison of the effectiveness of different approaches, i.e., here is a program to teach something or help the kid learn something; here is another program to help him learn the same thing: let's try them both. And it can get the novice user off to a flying start. In other words, you walk the teacher in; he doesn't know from beans about using a computer, but the program can turn him on. But the state of the art in *exchange* of instructional software is, to quote Joe Denk from North Carolina, appalling. Joe observes, "The Rand report declares rather flatly that the applications software is ready and available for aiding the evolution of higher education into a learning process."[3] Yet last spring in Philadelphia Layman and Fusey, in a paper to EDUCOM, said flatly: "Educational software does not exist or is virtually inaccessible."[4] Who is right, Rand or Layman and Fusey? Well, Joe Denk, who is in charge of the curriculum work at North Carolina Educational Computing Service, tells me that after the NSF Iowa conference a year ago this past summer he wrote to seventy of the authors of papers that were published in the proceedings of that conference. Each of those authors was chosen by Joe to write to because each one of them had specifically mentioned at least one instructional program that was up and running, and talked about it in his Iowa paper. Some of the authors talked about several. In response to Joe's request for a copy of their program, he has received to date at least one program from ten of the seventy people. The other sixty either have never replied or replied that the programs are not actually finished and/or weren't documented and/or weren't available. This year Joe is telephoning each guy who appeared at the NSF Dartmouth conference — phone calls this time. And he is only calling those who didn't appear at Iowa. Well, so far he has only gotten through to four of them. The weren't selected at random, but all four said no, they wouldn't give him a copy.[5]

In short, the software certainly does exist, but it is definitely not ready and available. And the vast majority of the software described in the Iowa and Dartmouth proceedings is not of the highly localized intensive variety that I mentioned before. There has been and continues to be very little reinforcement, positive or negative, to induce the learning of desirable documentation and dissemination procedure on the part of recipients for grants for software development. Why appropriate documentation and dissemination plans and performance are not made an absolute condition for the receipt of public funds in this area is absolutely beyond my power to comprehend. But I think it would be hard to devise a better way to ensure the reinvention of the wheel and then discourage comparison of one model of wheel to another.

As if these constraints weren't enough, of course the budget cuts of the past few years have forced many institutions to an agonizing reappraisal of all computing on campus.[6] Due to the factors already mentioned, I doubt that instructional computing will suffer anything less than proportional budget reduction on most campuses.

Well, what are we going to do? A number of new paths have been explored with you by other speakers at this conference. I would like to contribute just two thoughts. The first relates to the need for more effective sharing of front end software on a nationwide basis — the stuff that puts out the information and the help to the student. Judging by some recent experience, software exchange is a death trap for those who dare attempt it. COSMIC, DECUS, EIN, all are either comatose or moribund. But a few of us, being demented, refuse to be convinced by the suffering of others. Under Joe Denk's leadership, Karl Zinn, George Heller, Dan Bernitt, Ron Bloom, Ron Collins, John LeGates, Arthur Luehrmann, and others of us have formed a SIGCUE Task Force on program exchange. We calculate that fifteen hundred educational software packages of various kinds now exist. Joe last week produced a list of five hundred of them; I have a copy on the table. There is a lot of information missing; that is not a whole set of documentation, it's just a list. Who has them, how to move them, and how good they are, are the focal questions for this Task Force. We invite your assistance, individually and collectively, in answering them. And I do mean that to each of you individually or within your institutions or within EDUCOM.

My second contribution consists of a description of a stand-alone facility for small and medium-sized colleges, which I maintain can pay for itself in administrative computing and still be a flexible, relatively low-cost facility for batch and conversational instructional computing; i.e., the kids can ride piggyback on the administration and it won't cost them much. My recommendations are based on my experience with the system now existing at Beloit College in Wisconsin, a private liberal arts school with about eighteen hundred undergraduate students. The real credit for the development of this system at Beloit, the system that was used to build and make the programs available to the students, does not belong to me but to Len Swanson. He was formerly Director of Operations at Beloit's computing center, and is now a member of the staff of EDUCOM.

The basic hardware and software of a Beloit-type system is summarized in Exhibit 1. (The system at Beloit is based on an IBM 1800 rather than the similar but more common 1130 which is the basis for the system described here.) The total hardware and system software costs of the full 16 Teletype version (Configuration III) are just under $180,000, and the annual upkeep is $18,900. Amortized over five years, this yields a total cost of $55,000 per year, exclusive of personnel costs. Assuming an average utilization of 4 hours per Teletype per day, 300 days per year, and allocating *all* of these costs to Teletype users, we still have a cost of less than $3 per Teletype user hour. And I maintain that this system can deliver at least $50,000 per year of administrative and research computing services as well as simultaneous round-the-clock instructional computing via Teletype. Rental of the Configuration III Basic 1130 package itself, which would be "normal" configuration for batch work in administration and research, would cost just over $37,000 per year; thus this is the amount which would have to be paid for such services on a stand-alone basis. I believe that the "extras" of this system would be worth $13,000 a year to most administrations — they include a reasonable amount of Teletype time, a plentiful supply of interested, experienced, and relatively low-paid student programmers, and the use of the service programs (for example, in statistics, economics and accounting) the development of which will be encouraged by the existence of the full system.

Exhibit 1

Cost of a Small College Computer System
Based on an IBM 1130

Here is a software system designed to provide both conversational time-sharing for collegiate or school instruction and simultaneous batch processing for academic administration, all at a capital cost of less than $180,000. It is intended for use with an IBM 1130 computer, or similar hardware, in one of the configurations described below.

Configurations

All the configurations include the basic 1130 package, consisting of:

IBM 1131	2C Central Processor and time-sharing attachments (16K)
IBM 1132	Printer (about 100 lines per minute)
IBM 1133	Multiplex Control and attachments to support two disk drives (2310) (Provides 1 million words of storage)
IBM 1442	Card Read/Punch

I estimate the one-time capital cost of purchasing this equipment from IBM at $117,000, and the annual cost of an IBM Maintenance Agreement on this equipment at $3,900 per year.

All the configurations include the software system, consisting of:

- Software multiplexor
- Compiler for a conversational terminal language such as NUTRAN, JOSS, or BASIC
- Self-operating translator for batch-made execution of programs written in an administrative file-handling language.
- A large collection of instructional (CAI and service) programs for access from terminals.
- The development cost of such a software system should not exceed $150,000; if shared by 15 colleges, the capital cost would be $10,000 each. $3,000 per college per year should buy a lot of annual upkeep and improvement of the software system.

The 1130 System itself has its own Fortran IV Compiler, of course.

All the configurations include the basic Teletype package, consisting of:

4 Model 33 Teletype terminals, with 2 data sets each.

I estimate the one-time capital cost of this basic Teletype package at $3,700, including installation, and the annual cost of maintenance and rental of the necessary data sets at $3,000 per year.

The cost of disk packs (at $90 each), key punch machines, sorters, collators, etc., which some users may desire to purchase or rent, is not included in the following cost estimates, since we have found that they vary greatly from user to user.

Configuration I — Purchase Costs

Item	Capital Cost	Annual Cost
Basic 1130 package	$117,000	$3,500
Basic Teletype package	3,700	3,000
Software System	10,000	3,000
Add:		
Swapping drum	20,000	400
Totals:	$150,700	$9,900

The Annual Cost of $9,900 includes the estimated cost of all maintenance and rental of data sets, etc.

Thus purchasing Configuration I involves an initial capital outlay of $150,700 and an annual upkeep cost of $9,900 thereafter.

Configuration I can also be rented, of course, which will reduce (but not eliminate) the amount of the initial capital outlay, but increase the annual cost. Here are the estimated rental costs. (The initial capital cost figure of $400 for the basic Teletype package is the amount required to cover the one-time installation charges for the Teletype terminals and data sets.)

Configuration I — Rental Costs

Item	Capital Cost	Annual Cost
Basic 1130 package	$ 0	$31,600
Basic Teletype package	400	4,920
Software System	10,000	3,000
Add:		
Swapping drum	0	6,000
Totals:	$10,400	$45,520

The Annual Cost of $45,520 includes the estimated rental charge and estimated cost of all maintenance on all equipment.

The use of a swapping drum in Configuration I provides a core swap time of 0.15 seconds under ordinary operating conditions. The data on Configuration II below show that Configuration II is less expensive than Configuration I, but note that the core swap time for Configuration II is 1.8 seconds under ordinary operating conditions. In the event of expansion to Configuration III, described below, the user will benefit from having begun with Configuration I, generally speaking.

Configuration II — Purchase Costs

Item	Capital Cost	Annual Cost
Basic 1130 package	$117,000	$3,500
Basic Teletype package	3,700	3,000
Software System	10,000	3,000
Add:		
1 more 2310 disk drive	9,000	400
Totals:	$139,700	$9,900

Thus purchasing Configuration II involves an initial capital outlay of $139,700 and an annual upkeep cost of $9,900 thereafter. Disk storage is 1.5 million words.

Configuration II — Rental Costs

Item	Capital Cost	Annual Cost
Basic 1130 package	$ 0	$31,600
Basic Teletype package	400	4,920
Software System	10,000	3,000
Add:		
1 more 2310 disk drive	0	2,300
Totals:	$10,400	$41,820

Configuration III allows simultaneous operation of 16 to 32 Teletype terminals and requires the addition of 8K of core to Configuration I, or the addition of 8K of core plus a swapping drum to Configuration II.

Configuration III — Purchase Costs (in addition to those of Configuration I)

Item	Capital Cost	Annual Cost
8K of additional core	$18,000	$ 0
12 additional TTY's, with ancillary equipment	10,740	9,000
Totals:	$28,740	$9,000

Configuration III — Rental Costs (in addition to those of Configuration I)

Item	Capital Cost	Annual Cost
8K of additional core	$ 0	$5,500
12 additional TTY's, with ancillary equipment	$1,200	14,760
Totals:	$1,200	$20,260

NOTE:—The following is the basis of cost calculations on Teletypes:

Model 33 TTY: Purchase

- $820 per teletype as cost of hardware
- $50 per teletype as installation charge (usually includes installation of one data set)
- $25 per data set as installation charge (usually only one more required per TTY)
- $25 per month for rental of data sets (2 per TTY)
- $12.50 per month estimated maintenance cost per owned TTY

Rental

- $50 per teletype as installation charge (usually includes installation of one data set)
- $25 per data set as installation charge (usually only one more required per TTY)
- $102.50 per month rental of TTY, per TTY; includes rental of 2 data sets per TTY

NOTE:—The prices and descriptions of services stated herein are for information only and are subject to change. In particular, AUERBACH Associates does not sell or service products of the International Business Machines Corporation or the Bell Telephone System; prices on the components which must be obtained from these firms are based on trade information which the author considers reliable but does not guarantee.

I wish it was not necessary to justify this system in terms of its payback of administrative EDP services. I wish more college administrators and faculty shared my faith in the computer as a basic tool for effecting long-overdue changes in college curricula. But they do not — and considering the inefficiencies and waste in educational computing over the past ten years, their skepticism is worthy of my — and your — respect.

But why bother about instructional computing in small colleges? Surely Don Bitzer or some other equally innovative computer scientist will solve all of our problems for us by reducing the cost to 25 cents per terminal hour within a year or two. I sincerely hope he does — but, as far as I know, the PLATO hardware and software systems themselves do not write good instructional software all by themselves. I'm sure that PLATO and other projects will help President Nixon in achieving his goal of a lower cost, more productive American economy; but, like Ralph Nader, I'm more concerned about *what* is produced on the terminals than about their cost per student hour. And I know that high-quality work can be done at the smaller colleges.

I think small colleges offer a uniquely suitable environment for the development of interesting systems and first-class software, for three sets of reasons:

- The computing center in a small college is accessible to students and faculty — it is near their places of residence; it and its terminals can safely be kept open day and night, seven days a week; the complexity of the central processor with which it is equipped is within the mental grasp of a Freshman in Philosophy, who can safely operate it; an environment of sharing and equality can be created within it. Mechanically, their small systems are often far more adaptable and reliable than large systems — Beloit's coldstart time is 30 seconds; one major university's system, which crashes with alarming frequency, requires 45 minutes for each coldstart.
- Younger faculty at small colleges are generally more willing to innovate in instruction than are their contemporaries in larger institutions. Because there are fewer multiple section courses, they are under less pressure to toe the line on course content and the sequence of topics. Because they are not usually leading lights in their research fields, and do not plan to be, they can give more of their time to innovation. And because they are members of a smaller community, they can be less concerned with the trappings of academia — when your students all live within a mile of you, and you see each other almost every day, you are foolish if you try to maintain an authoritarian status. In short, the environment of shared work and mutual respect that is present in all first-class research efforts, and especially in software development, grows more easily in a small college community.
- I believe that the best way to use a computer on campus is as a means of supplementing successful instruction. I think the usefulness of CAI of the traditional sort at the collegiate level is very limited: at best, Skinnerian CAI can replace only those entire courses which are already Skinnerian in their pedagogy. Since I believe that such courses don't belong in a college curriculum in the first place, I want to see the computer used to handle these topics within particular courses which can be *better* learned with the aid of the computer — but I want this done within successfully taught courses, or, even better, by the students on their own initiative. I believe that this philosophy of the computer on campus is completely consistent with the educational philosophy of the best small colleges. And I believe that it is not consistent with the way in which the computer on the campus of most large universities is actually being used today.

As a modest example of what can be done, Exhibit 2 contains a list of the operational programs at Beloit as of the start of the current school year. Three years ago, the system did not exist. Two years ago, fewer than twenty programs were operational. Ninety percent of these programs have been written by students, under faculty supervision. Almost all are in Fortran IV, fully documented and available to anyone for a token charge. Ninety percent of them will run with only minor modifications on virtually any Teletype-driving system having a Fortran compilor. Most are original; some are adapted from the work of others. Almost all have been used by the students in at least one course.

Exhibit 2

List of programs available on the Beloit College Terminal System as of August 31, 1971, with a brief description of each program.

NOTE:—The SSIPP Final Report and descriptive specifications for most of these programs are available without charge; the specifications include sample output. Lists, card decks, or magnetic tapes of the programs, all of which are written in Fortran IV, are available at a nominal charge. For further information on all SSIPP programs (which include most of those listed below), contact C. R. Williams, Director of Operations, Computing Center, Beloit College, Beloit, Wisconsin, 53511. (Programs which were *not* developed by SSIPP are marked with an *.)

GENERAL	
*NUTRA	University of Nebraska's Conversational Programming Language
*TTT3D	3-Dimensional Tic-Tac-Toe Game
CRAPS	CRAP Game Based on the Multinomial Distribution
GRAPH	General Purpose Graphing Program
*EDTXT	Text Editing Program
*PNDAT	Punch/Restore Texts and Data Files From the Console
GLAZE	Does Calculations, Work Sheets and Labels For Glaze Tests
*EXPO1	A Non-Technical Population Control Game Based on Labor Force Manipulation.
MATHEMATICS	
*FNPLT	Plot User-Defined Functions of a Single Variable
*PCALC	Evaluation of Formulas in the Propositional Calculus
ECONOMICS	
SUMER	A Simple Economic Game for Non-Economists
MIC01	CAI In the Law of Diminishing Marginal Utility
MIC03	CAI In the Cobweb Model
MIC05	CAI In Marginal Revenue and Price Elasticity of Demand
MIC07	CAI In Short and Long Run Industry Equilibrium
MIC09	CAI In the Theory of Production
MAC03	CAI Macroeconomic Policy Game with 4 Keynesian Models
MAC04	CAI In Elementary Keynesian Economic Models, Including IS-LM Curves
MAC05	CAI Macroeconomic Policy Game, One Complex Model
MAC08	CAI Macroeconomic Policy Game, Hicks-Hansen Model with Endogenous Cyclical Characteristics
GEOGRAPHY	
CLAT1	Computer-Assisted Instruction Drill and Practice for Instruction in Geography
CLAT2	Computer-Assisted Instruction Drill and Practice for Instruction in Geography
CLAT3	Computer-Assisted Instruction Drill and Practice for Instruction in Geography

CLAT4	Computer-Assisted Instruction Drill and Practice Program for Instruction in Geography
CLAT5	Computer-Assisted Instruction Drill and Practice for Instruction in Geography
CLIM1	CAI In Climatic Regions
CLIM2	CAI In Climatic Regions
CLIM3	CAI In Climatic Regions
CLIM4	CAI In Koppen Classification
CLIM5	CAI (Multiple Choice Drill-and-Practice) in Middle Latitude West Coast Climatic System
*FACTO	General Factor Analysis, Matrix of Intercorrelation
GEOG1	CAI In Map Projections
*GRAMO	Gravity Model Calculation, Prediction, and Correlation
KOPEN	Determines the Koppen Climate Classifications for Any World Location
*LOCQT	Calculates Location Quotient
*POP	AGE Structure of a Population

GEOLOGY

*CIPW	Normative Calculation for Igneous Rocks
*ERM	Experimental Rock Mechanics
*EVOL	Evolution Game
*GRSZ	Grain Size Analysis
*SPHER	Grain Sphericity

GOVERNMENT

GOVO1	Foreign Policy Simulation

SOCIOLOGY

SPS03	Exercise in Group Dominance Patterns

PSYCHOLOGY

PSY01	CAI In Probability and Experimental Method
PSY03	CAI In Experimental Design; Emphasizes Analysis of Variance
PSY05	CAI In Experimental Design; Emphasizes T Tests
PSY07	CAI In Experimental Design; Emphasizes Correlation Methods
PSY09	CAI In Experimental Design; Emphasizes Chi-Square Tests
ITAN	Item Analysis (Point-Biserial Correlation)
CORRE	Correlation Coefficient and Reliability Coefficients

PROBABILITY AND STATISTICS

STAT1	CAI In Type I and Type II Errors and Sample Size
STAT2	CAI In Binomial Confidence Intervals
STAT3	CAI In Risks and Costs, Normal Distribution
MRCAP	Multiple Regression, Correlation and Prediction
ANVAR	Analysis of Variance
SCHEF	SCHEFFE Tests on Contrasts
TMOMN	First Four Moments of Grouped Data
TTALY	Calculates Mean and S.D. for a Set of Data
TTAB1	Tabulates Frequencies for One-Way Classification
TTAB2	Tabulates Frequencies for Two-Way Classification
TGAUS	Generates Up To 250 Random Normal Numbers
BINOM	Binomial Probabilities
PASCL	Pascal (Negative Binomial) Probabilities
POISN	Poisson Probabilities
MULNM	Multinomial Probabilities
HYGEO	Hypergeometric Probabilities
NEGHY	Negative Hypergeometric Probabilities
NORML	Normal Probabilities
CHISQ	CHI Square Probabilities
STUDT	Student's T Probabilities
SNEDF	Snedecor's F Probabilities
CSTST	CHI Square Test for Up To 3 By 3 Tables, Elegant Output
CSTNM	CHI Square Test for Up To 11 By 150 Tables
CSTGF	CHI Square Test of Goodness of Fit (1 By N Table)
TTEST	Student's T Tests on Sample Mean(s)
FTEST	Snedecor's F Test on Equality of Population Variances
NPAR1	Kolmogorov-Smirnov One Sample Test

NPAR2	Kolmogorov-Smirnov Two Sample Test
NPAR3	Mann-Whitney U Test
CNIBN	Confidence Intervals for Binomial Distribution
CNIPA	Confidence Intervals for Pascal Distribution
CNIPO	Confidence Intervals for Poisson Distribution
CNIHY	Confidence Intervals for Hypergeometric Distribution
CNINM	Confidence Intervals for Normal Distribution
CNICS	Confidence Intervals for CHI-Square Distribution
CNIST	Confidence Intervals for Student's T Distribution
CNISF	Confidence Intervals for Snedecor's F Distribution
PWRBN	Power of Tests Based on Binomial Distribution
PWRPA	Power of Tests Based on Pascal Distribution
PWRPO	Power of Tests Based on Poisson Distribution
PWRHY	Power of Tests Based on Hypergeometric Distribution
PWRNM	Power of Tests Based on Normal Distribution
PWRCS	Power of Tests Based on CHI-Square Distribution
PWRST	Power of Tests Based on Student's T Distribution
PWRSF	Power of Tests Based on Snedecor's F Distribution
SSZBN	Minimum Sample Size Needed for Binomial Confidence Interval
SSZHY	Minimum Sample Size Needed for Hypergeometric Confidence Interval
SSZNM	Minimum Sample Size Needed for Normal Confidence Interval
SSZCS	Minimum Sample Size Needed for CHI-Square
SSZST	Minimum Sample Size Needed for Student's T
SSZSF	Minimum Sample Size Needed for Snedecor's F
VARYN	Graphs Binomial Density Functions with Varying N
VARYP	Graphs Binomial Density Functions with Varying P
BNGTP	Bayesian Game Tree, Binomial or Poisson Probability
MCXBR	Simulation of Estimation of Population Mean by Repeated Samples
MCVAR	Simulation of Estimation of Population Variance by Repeated Samples
MCCOR	Simulation of Estimation of Population Correlation by Repeated Samples
MCCSQ	Simulation of Sampling Behavior of CHI-Square Distribution
MCSTT	Simulation of Sampling Behavior of Student's T Distribution

ACCOUNTING

PVL01	Time Required To Retire a Given Capital
PVL02	Present Value of a Future Capital Sum
PVL03	Future Value of a Capital Sum (Compound Interest)
PVL04	Present Value of an Annuity
PVL05	Future Value of an Annuity
PVL06	Implied Interest Rate of an Annuity or Capital
PVL07	Implied Rent of an Annuity
FINSM	Financial Management — Decision Making Simulation

OPERATIONS RESEARCH

SIMQU	Simulation of Behavior of Queues (Waiting Lines)
LNPRG	General Linear Programming Analysis
TPERT	General Pert Analysis
UNITX	Production Scheduling and Inventory Control
MIDTX	Simplified Production Planning and Control Simulation

FRENCH LANGUAGE

*FVDR1	Drill on Gender of Common Nouns
*FVDR2	Drill on Sequence of Tenses After SI Clauses
*BOVA1	Drill on Pronoun Order and Agreement

ARITHMETIC DRILL ROUTINES

*ANDY	Drill and Practice in Addition
*SANDY	Drill and Practice in Subtraction
*MANDY	Drill and Practice in Multiplication

These programs, and the students who wrote and use them, are the proper justification for the Biloit system — or any other computing in education. In the

ERIC

best article I have read in many months, William S. Dorn of Denver observes that, "One must always keep in mind that education is the reason for the existence of a university . . . research activities are only justified in a university on the basis of their contributions to the caliber of the education . . . the administration exists because of and for the benefit of the students. . . . Ultimately, the computing center exists only as a means for providing a better education for the students."[7] This alone is a necessary and sufficient condition for all of us to recognize and meet the need for a better front end in instructional computing.

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[3] Denk, J. R. "Exchange of Applications Programs for Education — A National Stalemate" INTERFACE, Vol. 5, No. 1, February, 1971. The Rand report referred to by Denk is Levien, R. et al, Rand Corporation, THE EMERGING TECHNOLOGY: INSTRUCTIONAL USES OF THE COMPUTER IN HIGHER EDUCATION. Draft of R-503-CCOM/NSF/RC, September, 1970.

[4] Lehman, R. and Fucci, E. "Regional Systems for High Schools and Small Colleges" THE FINANCING AND ORGANIZATION OF COMPUTING IN HIGHER EDUCATION: 1971. EDUCOM, 1971.

[5] Denk, J. R., private communication to M. A. Hall, with permission to quote granted. The NSF Iowa Conference is reported in PROCEEDINGS OF A CONFERENCE ON COMPUTERS IN THE UNDERGRADUATE CURRICULA, Iowa City: NSF and The University of Iowa, 1970. The NSF Dartmouth Conference is reported in PROCEEDINGS OF A CONFERENCE ON COMPUTERS IN THE UNDERGRADUATE CURRICULA, Hanover: NSF and Dartmouth College, 1971. (The Dartmouth Conference PROCEEDINGS were out of print as of October 15, 1971.)

[6] A recent report on three such examinations is given in "Campus Computing — Making the Users Pay Their Way" COMMUNICATIONS OF THE ASSOCIATION FOR COMPUTING MACHINERY, Vol. 14, No. 3, March, 1971.

[7] Dorn, W. S. "Implications of Educational Innovations" SIGUCC Newsletter, published by the ACM Special Interest Group on University Computing Centers, June 30, 1971.

THE UNIVERSITY OF COLORADO COMPUTING CENTER

by E. R. Krueger
University of Colorado

The university academic computing center exists to support the university's instruction and research programs. The implications of that statement of providing service to the academic community in these times of extremely tight money involves policies and procedures upon which it is very difficult to generalize. Many center directors might say, "Through conflict comes growth." This talk, however, is oriented as if from one of the trees in the forest. As such, I would like to give you an impression of what it is like to serve the academic community; that is, meet research needs while improving instructional capabilities in a public institution, the University of Colorado environment.

The University of Colorado has an enrollment of some thirty thousand students. In addition to the main campus located in Boulder, general academic centers exist at Denver and at Colorado Springs. The University also operates a medical center in Denver. In its role of providing academic service, the Computing Center has several programs to develop new applications. Included in this category is a research effort in computer graphics and an active program in library applications development. The current hardware complement of the Center includes a dual CDC 6400 configuration with nine remote batch terminals, one on every campus, one at the Colorado Department of Highways, for whom the University provides engineering-oriented computing service, and one at Metropolitan State College located in Denver. This additional role of sharing of facilities is an implementation of the classic role of a public university.

Conceptually, the Center is a computer utility which provides bulk storage for data and program files and a broad based applications library. Hardware and software capability enables interfacing of remote batch and interactive terminals, that is, alphanumeric and graphic devices; in addition we have provision for interfacing remote digital control processors for the purpose of data collection. The communications systems which are employed include telephone, microwave, and two infra-red light links which were developed at the University and are utilized for high-speed data transmission.

The general environment is characterized by dynamic changes in hardware and software perpetrated by active involvement of many disciplines. The Center operates within the University as an auxiliary enterprise, much like the bookstore. As shown in Figure 1, the director reports to the Office of the Provost. An Advisory Committee is structured to include representatives of each school, college, laboratory, or institute which makes significant use of the facility. Otherwise the organization is a usual center organization. The assistant to the director is a budget and contracts man.

The organization of the Center within the University implies close evaluation of (1) cost to the Center to provide adequate service and (2) cost to the user to do his job. Relevant to the first, we have implemented separate cost centers within the Computing Center. That is, cost centers exist for operating, applications programming, and for the library. The second item I mentioned, that is, cost to the user to do his job, includes the ease of communication with the machine, documentation, library and consulting, and turn-around — and turn-around, and turn-around.

The operating account, that is, the one which represents the operating cost center, is shown with a percentage breakdown by expense category in Figure 2. As you might expect, a heavy emphasis is on hardware. Most personnel costs, all supplies, and equipment costs are recovered by the charges for the use of the machine resources. Overhead and most operator costs are recovered through a minimum charge per job. Cost to the user, in terms of the dollar cost, is based on the following goal: each user should benefit equally because the other user is on the machine. What that means is, we don't subsidize one user with income from another. That is, we don't want the students riding piggyback on the other users.

Because of the charging goal, and because of rapid growth in instructional jobs, i.e., approximately 30% per year, the minimum charge per year tends to impact this category of user. However, a re-evaluation of the minimum charge each year, based on predicted increase in job usage, enables instructional support of the kind of growth in usage we have learned to expect with a much more modest increase in University-funded support. Relative to the goal stated earlier, this concept appears sound; that is, most of the cost for processing a student job is in operator handling.

Last fiscal year, 350 courses at the University used the computer. Well over ten thousand students were involved. Instructional computing dollars were and are allocated through the Computing Center to each school and college, based on past usage and available dollars. The appropriate dean suballocates to each department and the chairman of each department then suballocates by course. Allocation by student is coming; at this point the students know what their job costs but they do not know what balance is left in an allocation. To have the students know what their job costs and to know how many dollars they have used in the course of doing their work is an appropriate, from our point of view, piece of information to provide. Figure 3 shows some typical costs per student for a few selected courses at the University.

A couple of data points here: Last November we executed 6,600 jobs from the Denver Center terminal, almost all instructional, at a cost of under $4,000 and used less than four hours of central processor time. The engineering college, which has a high-speed terminal — that is one of those on a light link — on a busy day will send one thousand batch jobs to be processed at the Center. Figure 4 shows our total job load since 1962. Turn-around times at the Center have continually improved while the load has grown so rapidly. It runs anywhere from instantaneous on through thirty minutes to perhaps as much as two hours. The latter is very seldom.

Development of new applications capability is derived from both the library and research efforts. Relative to the library activities, the Center has an on-going effort to share library applications with other centers. We are now in fact in the process of implementing an on-line applications library retrieval system which will enable other centers to tap our library programs and their corresponding documentation. Additional applications are derived at the University through various faculty committees, representing mathematics, statistics, engineering, business, and management science. Through these committees, grants of computer time are awarded to faculty who submit proposals to research and develop new applications packages. The Center library programming personnel assist the faculty in completing and documenting all the additions to the applications library.

Additional applications capability is derived through Center research programs. These efforts, of course, provide additional monetary support to the Center while developing applications capability which the University otherwise could not afford to develop. The primary research effort at this time is in computer graphics. The project started in 1967. Utilizing one display device we developed a set of display drivers to interface to the standard operating system. Based on this capability, we now have 29 applications packages, many of which are regularly used in instruction and research. Applications packages exist in many areas, including mathematics and engineering. One in psychology is used for analyzing decision making processes. It has been used in water resource analysis, management decision analysis, and for instructing medical students in diagnostic analysis. An engineering package which has received quite a bit of attention is one developed under contract with the Federal Highway Administration. To graphically provide a driver's eye view of a designed but not constructed highway, the programming system utilizes survey data to produce images which can then be animated so as to simulate the driving experience. A perspective view illustrating the output is shown in Figure 5.

In summary, I would like to attempt to generalize by saying that the community of computing center directors has done much toward developing computing capability both in applications systems and in providing the hardware to access those systems. The current and anticipated funding restrictions impose even tighter constraints in that we must continue to provide improvements of service to our respective academic communities in a very cautious environment of fiscal responsibility. This involves generating growth in usage and new hardware and software systems to reduce the cost of computing, and that takes dedicated involvement to succeed. This involvement alone, however, is not totally adequate. It must be supported by sincere involvement on the part of faculty, students, and of course the university administration.

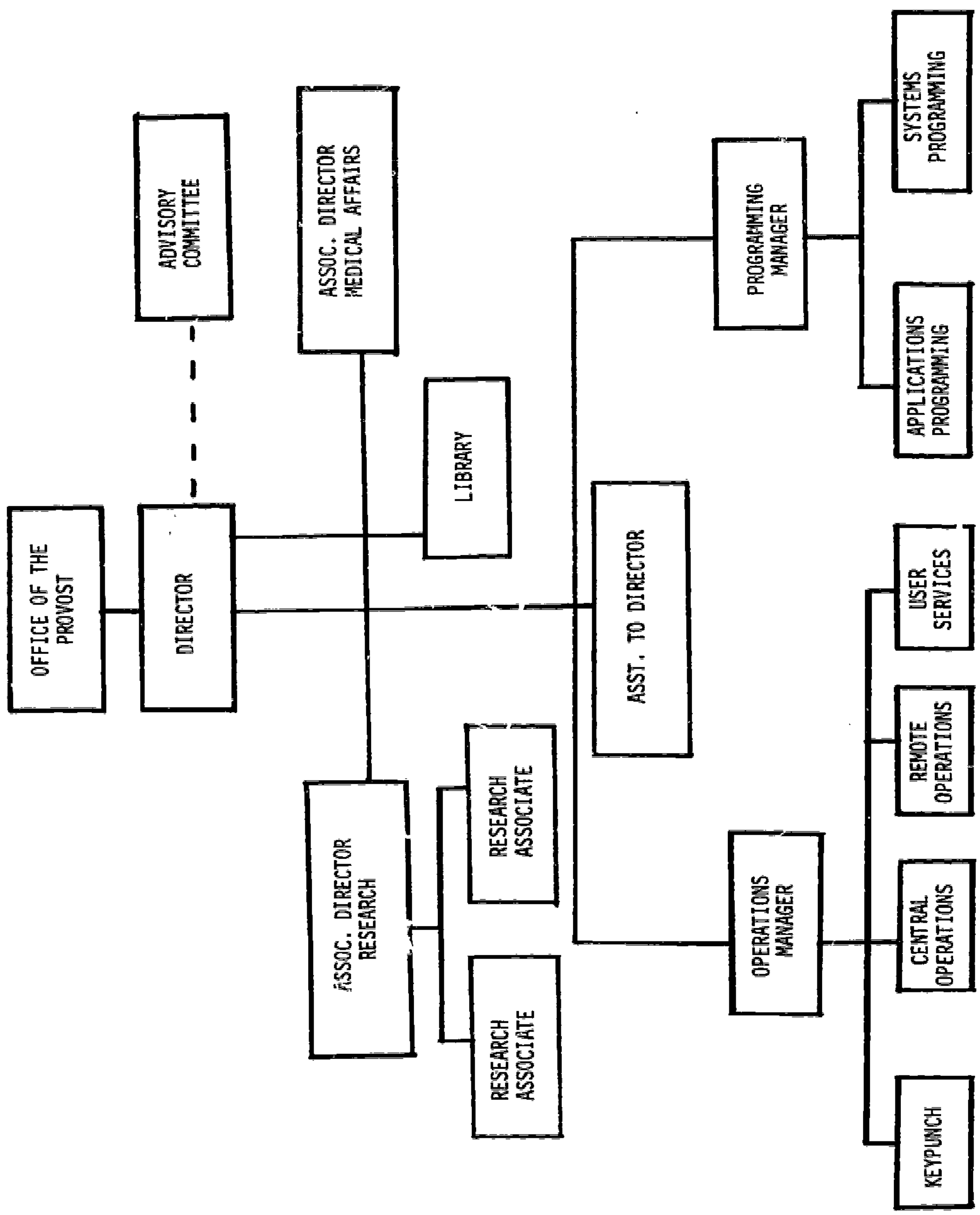
OFFICE OF THE PROVOST
DIRECTOR
ADVISORY COMMITTEE
ASSOC. DIRECTOR MEDICAL AFFAIRS
LIBRARY
ASST. TO DIRECTOR
ASSOC. DIRECTOR RESEARCH
RESEARCH ASSOCIATE
RESEARCH ASSOCIATE
PROGRAMMING MANAGER
APPLICATIONS PROGRAMMING
SYSTEMS PROGRAMMING
OPERATIONS MANAGER
KEYPUNCH
CENTRAL OPERATIONS
REMOTE OPERATIONS
USER SERVICES

Figure 1

COSTS TO THE CENTER
(Fiscal Year 1972)

Personal Services and Benefits	23%
Administration Operations Systems Analysts/Programmers	
Supplies and Expense	10%
Equipment	61%
Amortization Rental Maintenance	
Overhead	6%
Administrative Service Recharge Building Rental	

Figure 2

INSTRUCTIONAL COST/STUDENT
(Fiscal Year 1971)

C.Sc.	201	Introduction to Computer Science	$56.64
C.Sc.	465	Intermediate Numerical Analysis 1	$32.63
C.Sc.	501	Introduction to Digital Computers	$92.93
E.E.	322	Electronics 2	$15.00
C.E.	405	Structures 5	$13.33
EDEE	101	Fundamentals of Design 1	$25.00

Figure 3

NUMBER OF JOBS PROCESSED ANNUALLY BY CENTER FACILITIES

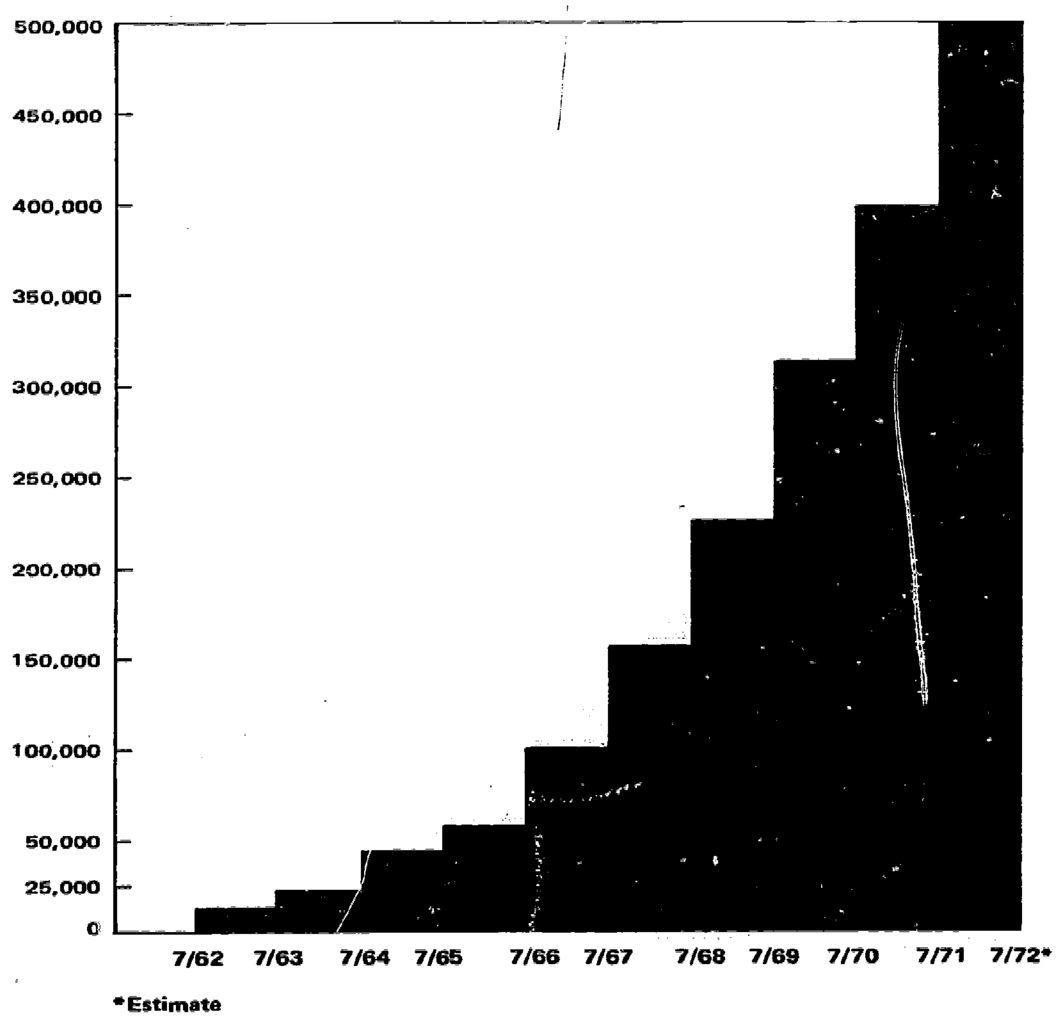

Figure 4

Figure 5

COMPUTER-ASSISTED INSTRUCTIONAL SYSTEMS FOR HIGHER EDUCATION: PROBLEMS AND PROSPECTS

by Wilson Judd
University of Texas at Austin

University of Texas CAI Laboratory and 1500 System

The UT CAI Laboratory is envisioned as functioning in two complementary roles: (1) research directed at improving computer-assisted instruction, and (2) the development and implementation of CAI in the university setting. To carry out these functions, the Laboratory maintains an IBM 1500 instructional system. The characteristics of this system relevant to this discussion are that it has a capacity for five disk packs and controls ten instructional terminals. Two of these terminals are not currently available to students but are used by proctors and programmers. Of the remaining eight, two have 1518 typewriters while the other six use the 1510 CRT and keyboard configuration. All eight have image projectors and light pens, and six are supplemented by 1506 fast-access audio units.

During the current semester, terminals are available for student use twelve hours per day, from 8 a.m. until 10 in the evening. The noon and supper hours are used for system utility as is the period from 10 p.m. until midnight. Saturdays are devoted to special projects such as experiments and, currently, an informal course in APL for high school students.

Student scheduling is on an *ad lib* basis in terms of one-hour blocks. That is, students can call in and make appointments to use a particular course during any of the regular hours. Since a major course may require up to four disk packs and since students tend to spread themselves out through a course, the factor which usually limits the number of students who can be on the system at one time is the number of disk packs rather than the number of terminals. If we required all students working on a particular course to schedule during restricted hours, the limiting factor would be the number of terminals, but thus far such a restriction has not been deemed necessary.

This semester, the system is supporting two major programs which are being used in University classes — a laboratory for a statistics course and a survey of handicapping conditions (developed by the Penn State CAI Laboratory) which is being used in an introductory course in special education. The first requires an average of 15 hours of computer time; the second, 25 hours. In addition, a number of students make use of a precalculus math course for a variety of purposes and a small group of Latin American students are taking a course in English punctuation. During the first three weeks of the semester, the system was also used to present the Arabic program as a component of a University Arabic course. While system use was heavier when Arabic was being run and will be heavier again at the end of the semester, terminal utilization is only about 35% at this time.

The 1500 system was designed for research purposes. As was mentioned, this is one of the Laboratory's activities and for these purposes the system is fairly satisfactory. The flexibility provided by the sophistication of the terminal devices is quite advantageous. System response time is slower than might be desired for some purposes. Data retrieval often appears to be unnecessarily cumbersome, but, in general, the system provides a powerful and convenient research tool. Use of the 1500 in a production mode is less satisfactory. The system as it is configured at the University of Texas is much too small to support an extensive curriculum effort.

There are a number of factors, however, which have interacted to limit the extent to which we have been able to establish CAI as an accepted part of the University of Texas curriculum. The costs of developing and using CAI programs are too high. For example, the Arabic course provides about seven hours of interactive student instruction. It costs about $3,600 in personnel time to produce the course and an additional $1,200 to debug it. The program was produced as part of the author's dissertation, and her time is not included in these figures. But since it entailed full-time work for several months, the value of her effort was estimated at about $6,000. Finally, $2,100 worth of computer time was required for the course's production. Thus, the total cost of producing the program was $13,000 including the author's time. But this still doesn't include evaluation.

There are two reasons for these high costs. The first is our insistence on a detailed instructional design approach to the production of the materials. Second, and more important, is the time and expense required for coding and debugging. We recently have attempted to reduce these costs by the development of preprocessor and macro expander programs designed to facilitate the translation of author's draft materials into error-free computer code. The preprocessor was used during the summer for several minor coding projects and thus far appears to be quite satisfactory. It will receive a more thorough evaluation this fall in the production of a full-semester computer-managed instruction course.

Because of the system's relatively expensive terminal hardware and the limited number of terminals available at our facility, student-terminal-time costs are quite high — about $5.00 per hour. There are a number of different ways such costs can be computed and we have had some debate among ourselves as to what the exact value should be, but it does appear that the appropriate figure is in the neighborhood of $4.00 to $7.00. This value is not currently competitive with the cost of conventional instruction at the University of Texas. The cost could be reduced somewhat by increasing the number of terminals and employing a less flexible scheduling scheme, but we do not feel that the savings from these actions would be that significant. If institutions placed a dollar value on the time students spend preparing for class as well as class time, the comparison would be more favorable to CAI.

For example, evaluation of the Arabic program in comparison to conventional classroom instruction found that four to eight hours of terminal time plus four hours of class time without homework assignments was more effective than 18 hours of regular class with its usual complement of homework.

We have encountered a number of institutional constraints on the further implementation of CAI at the university level. One of the more interesting of these concerns the source of the funds to be used for a CAI program. Since cost per student hour can be reduced if development expenses are distributed over a large population of students, lower division undergraduate courses would appear to be the most promising market for CAI in a university. These courses, however, are usually taught by graduate students. If a department spends funds allocated for these courses on a CAI program, it has lost one means of supporting its graduate students. Given the relative importance attached to the quality of graduate as opposed to undergraduate training, very few departments are willing to divert funds to CAI.

In view of these several considerations, the Laboratory has changed the focus of its major development efforts. During the next few years we will be working with MITRE Corporation in attempting to demonstrate cost-effective computer-assisted instruction in a junior college setting. We think that there are a number of reasons why junior colleges will provide more fertile ground for the growth of CAI than have universities. The most interesting aspect of this project, however, involves the development of a CAI system designed to be cost-effective.

The TICCIT System

The system we are concerned with is called TICCIT (Time-shared Interactive Computer-Controlled Information Television). The system hardware and sofware are being developed by MITRE Corporation, while the University of Texas and Brigham Young University are developing five courses in mathematics, English, and computer science. MITRE's philosophy in developing TICCIT has been to maximize the use of existing, off-the-shelf hardware while also attempting to capitalize on advances in relevant technology. TICCIT has been designed as a small, relatively inexpensive system which an individual school could afford to buy or lease. MITRE's analysis of CAI facilities found that cost per terminal hour increased rapidly as the number of terminals dropped below 100 but remained relatively stable above 100. The basic TICCIT system was, therefore, designed to support 128 on-line terminals.

The computer subsystem is based on two mini-computers. The first, a Data General SUPERNOVA with 32K of memory, serves as the main processor. The second, a 12K Data General NOVA 800, serves as a terminal processor, handling the fast-reaction, stereotyped interactions with the student terminals. The main processor is supported by slow, low cost peripherals — card reader, line printer, and one magnetic tape unit — and by two large moving-head disk drives to contain the data base and two fixed-head disks to serve as virtual memory.

The smaller, terminal processor receives and processes keyboard entries from the terminals and generates new displays to be sent back to the terminal. It is supported by two fixed-head disks which are used to store previous frames for updating and retransmission — for example, echoing characters to the student's terminal as they are typed. The terminal processor controls three peripherals, a keyboard signal processor, an audio message generator, and a television character and vector generator. This last device converts character codes and line drawing commands into composite TV pictures, outputting new pictures at a rate of up to 60 per second. Since the device has a large programable character definition memory, the terminal processor can change character fonts to suit different subjects and instructional styles.

TICCIT utilizes a wide-band coaxial cable (as is used for CATV) to distribute signals to the terminals and carry student responses back to the computer. In some installations, TICCIT might have a dedicated cable system but in other situations it could utilize a single channel on an existing CATV system. When the terminal processor assembles a frame for a particular terminal, it adds the number of the terminal to the frame. The number is coded as 16 black and white dashes immediately before the vertical retrace. The frame is then injected into the cable system as a regular TV field, the total signal duration being a 60th of a second. Thus, 60 individual displays can be transferred to the terminals per second.

Each terminal contains a decoder which examines all of the frames on the cable. If a frame's address matches the decoder's address, the decoder "grabs" that frame and records it on a video tape recorder at the terminal. The video tape recorder then serves as a refresh memory for the terminal's television set. Keyboard signals resulting from the student's responses are time-division multiplexed by the terminal electronics onto the same cable that carried the video signal to the terminal. Thus, TICCIT requires a cable system with two-way signal flow capability. The newer CATV systems now being designed and built have this two-way capability.

A major economic factor in the design of a CAI system is terminal cost since this cost must be replicated *n* times for each of the *n* terminals. In its current configuration, the TICCIT terminal consists of a standard television receiver, a video tape recorder, keyboard, and a minimal amount of control electronics. The most expensive component in the terminal is the video tape recorder. Several companies will introduce cassette video tape recorders in the next year, costing in the range of $700 to $800. According to company reports, the price should drop to $400 to $500 in the near future. One of the intriguing aspects of the terminal is the availability of a video cassette recorder for non-CAI use. For example, interactive CAI could be complemented by the use of short, single concept films presented by means of video cassettes.

MITRE has taken an interesting approach to the production of instructional materials for TICCIT. Previous systems, such as the 1500, used special purpose programming languages that attempted to compromise between what an author might find natural and what was easily processed by the computer. While this approach enables naive authors to produce simple instructional programs, the language becomes a liability in any attempt at complex information processing. More recently, the trend seems to have been toward the use of more powerful, general purpose languages, but this approach poses difficulties for most authors. MITRE's intention is to try to provide the author with the best of both worlds by developing software tools that will allow him essentially to create authoring languages idiosyncratic to the characteristics of the course material and to his particular authoring style. This is being done by the development of a general purpose programming language, the TICCIT language, and the construction of a powerful macro language processor. The author will create his particular stylistic language by defining macros appropriate to his display and response processing needs. It is anticipated that most of the instructional programming will then be done in terms of these macros, with recourse to the TICCIT language when necessary.

Chapter 5

Library Systems: Increasing Resources & Decreasing Expenses

OVERVIEW

by Frederick Kilgour
Ohio College Library Center

The panel on library resources brought out several examples of increasing resources and decreasing expenses in the discussion of the Ohio College Library Center and Ohio State University libraries' systems.

Library resources which are available to users have been increased dramatically in both the Ohio College Library Center and the Ohio State University libraries' systems. The OCLC system is primarily utilized by member libraries at this time for cataloging books and has enabled users to increase the rate of production from two to three titles per hour to upwards of 10 per hour. The catalog cards produced are equal or better in quality to those produced on manual systems and are available in any of 3,000 different formats. Cataloging is done on Irascope terminals which enable the cataloger to utilize existing bibliographic information from previous cataloging stored in the central file.

Another increase in library resources available to Ohio users has been brought about through the application of the OCLC system to interlibrary loan processing. A librarian in any member library can determine within seconds the location of a particular book at any of the member schools by calling the catalog record to the screen of the terminal through the Library of Congress catalog number or by a truncated author-title or title search key. This system will be expanded to allow message switching which will enable an institution to request a title from another institution.

Increased resources in circulation systems have been demonstrated by the Ohio State University libraries. A campus user of the libraries can telephone the library, inquire about a book by author, author-title, title, or call number, and learn whether the book is available and when he might expect to receive it by campus mail.

The economic advantages arising from these systems are enormous. Estimated net savings for the approximately 50 members of the Ohio College Library Center equal $400,000 per year. All of these savings are assigned just to the cataloging process. The other benefits of the system such as the union catalog information, the message switching communication, and use of the bibliographic data in the system are available without charge above the cost of cataloging. Still another saving is being realized by some member university libraries as they increase the processing of library materials without increasing staff.

Forecasts of savings as well as an explanation of some of the technical aspects of both the OCLC and the OSU systems are included in the following papers.

OHIO COLLEGE LIBRARY CENTER SYSTEMS

by Frederick Kilgour
Ohio College Library Center

I am going to talk about the Ohio College Library Center; what it is; what it hopes to do; what it's doing; what it costs; and what it saves. Phil Long is then going to talk about some of the technical aspects of what we are doing and some of the lessons we have learned: Gerry Guthrie will then describe the OSU circulation system.

The Ohio College Library Center is a separate corporation, incorporated in the State of Ohio in July of 1967. It has been operating since September of 1967 and has had the trials and tribulations of a new corporation.

The center has two major objectives. One is an academic objective and the other is an economic goal. The academic objective is to enable libraries to participate in the educational and research programs of their institutions. At the present time, libraries serve. That service is not enough as has become quite clear to most although I don't think most have analyzed what it is that's inadequate about libraries. Libraries have got to begin to participate in the actual programs of their institutions. In short, one of our ultimate goals is to make all kinds of information available to users when and where they need it, but for the short-term goal, we are going in the direction of making bibliographic information available to then. when and where they need it. Gerry Guthrie will describe the major departure from classical librarianship that achieves remote access to libraries today.

We also intend to make the library resources of the state available to each institution, and this is perhaps the main goal of our first application although we talk persistently about cataloging in the first application and not the availability of resources.

The economic goal is to diminish the rate of acceleration of per-student costs in libraries. You all know that the main problem in academia as a whole and in academic libraries in particular is the problem of per-unit costs, per-student costs are going up at a rate far higher than per-unit costs in the general economy. In academia the rate of rise ranges from five to seven percent instead of the two to three percent in the general economy. The exponential curve of per-student costs is rising rapidly at this present time, above the general price index because there is no productive technology in academia — no effectively productive technology at the present time. Computer assisted instruction certainly holds out a hope to knock down or decelerate this bankruptcy curve with which we are confronted, and the same kind of technology, computer technology, holds the same hope for librarianship.

This problem of the rising costs is not one generated by the war in Southeast Asia or by inflation. When inflation is lowered to a three percent level and there's no longer a war in Southeast Asia, we are still going to have the same economic problem. There are some, I know, that hope that somehow there will be a solution when one or the other of these events occurs. But we will not achieve the solution until we are able to invoke a continuously increasingly-productive technology in libraries and in the rest of instructional activities in colleges and universities.

We have designed a pathway to these two goals in an overall system design that was broken down into five major subsystems. The first we perhaps inappropriately call shared cataloging; the second is serials control; the third is a technical processing system; the fourth is remote catalog access and circulation control. (Gerry will talk about a particular application of this technique at OSU); and five is user access by subject and by title.

Once we had designed this comprehensive system, we set about selecting equipment for it. We were forced by the enormous number of variables encountered in the process to use simulation in selecting a computer, and Phil Long will talk about some of the details of how that simulation was done. I might say first off that none of the ten machines that were proposed to OCLC would do the job on the first challenge. Needless to say, this finding was most discouraging, and it was only with the skillful work of Phil and the simulation analyst that they were able to redesign operating systems in the ten computers, obtain the manufacturers' approval for that redesign operating systems in the ten computers, obtain the manufacturers' approval for that redesign, and resimulate. Then we were able to identify three computers that would do the job. Next, we carried out a trade-off study among those three and selected one, Xerox Data Systems Sigma Five. We followed the same procedure, without doing a computer simulation, for selecting a terminal. There were some fifteen terminals involved in the study and the final trade-off study included three. We selected a little-known terminal, produced by Spiras Systems, Inc., called Irascope Model TE. It is specifically designed for text manipulation and for the manipulation of bibliographic records.

Our schedule for implementation was to get under way in January 1970 and to spend eighteen months bringing up the first system, which is basic to the other five systems. We now have a grant that will enable us to work on subsystems two, three, and four that I mentioned, and these three are supposed to be operational by the first of January, 1973. In the ensuing year or eighteen months, we will bring up the subsystem for users' access by title and by subject.

The advent of Mark II bibliographic records on magnetic tapes from the Library of Congress in the spring of 1969 led us to institute an off line system for cataloging that had some major advantages. As it turned out, it would have been absolutely impossible to bring up on line cataloging and the production of catalog cards for fifty institutions at the same time because of the tremendous amount of work involved for both the Center and the 49 participating institutions. We operated for a year and produced some 440,000 catalog cards for over ninety thousand titles that were cataloged on the off line system before it was discontinued for operation on the on line system.

On the first of July when we were supposed to go on line, we did so with a training program that was subsequently improved and continued to operate until late August when we threw the switch and went on line for live production of cataloging.

There are three accesses to the on line located in Columbus. The equipment is in the machine room of the Learning Resources Computer Center of OSU. At the present time, the computerized catalog contains about a hundred and sixty-five thousand catalog entries, the equivalent of a library of about a quarter of a million volumes, a library larger than eighty percent of the academic libraries in Ohio.

In each institution there is one or more Irascope terminals that a cataloger uses to seek bibliographic information — cataloging information resulting from previous cataloging and in the central file. The search is carried out by using a Library of Congress card number, of which I am sure most of you are unaware, that resides on the verso of the title page of most American imprints; or by an author-title access; or by a title access.

To catalog a British book that does not have a Library of Congress card number, the cataloger enters a truncated search key that consists of the first three characters of the author's name and the first three characters of first non-English-article word of the title. She then depresses a key labeled DISPLAY REC'D and then another key labeled SEND. Ninty percent of the time there is a reply back from the central system within three seconds. Usually, the reply is the record that the person is seeking. The rest of the time it is a series of truncations of records because there is more than one entry that fits that six-character key. These entries are numbered, and if it is the third one that the cataloger wishes, she simply depresses "3", DISPLAY REC'D, and SEND. Then the complete record is displayed. If the cataloging library uses Library of Congress cataloging completely, as the majority of libraries in Ohio do, the cataloger then enters the LC call number in the book, pushes PRODUCE and SEND, and the cataloging is done.

That evening catalog cards are produced at the Center in final form, with all the headings printed on them, arranged to be filed in individual catalogs in the individual libraries. The libraries need do nothing with these catalog cards except the final filing. In manual cataloging, there are two, three or four books done in the course of an hour in most libraries. In the early operation of the Center, there are libraries that are doing ten an hour, fourteen an hour and one individual in that second library does twenty-two an hour.

This morning we were supposed to add an additional type of cataloging to the system, but we didn't quite make it. Those who log in on the system today are receiving a message saying that input cataloging will not be available until Monday. Input cataloging employs cataloging information not already in the central system so that it is necessary to do original cataloging. A cataloger does input cataloging by calling up a work form, filling in the work form, and communicating the information to the Center. Within a fraction of a second that cataloging — on Monday — will be added to the central files and indexed so the new cataloging record is available to anybody else who will be cataloging the book.

I should perhaps say to you right now that we have three other accesses that we intend to add. One will be by author alone. The research work has been done on this index, and we have now to make a decision as to just which search key we are going to use. There will also be an access by call number, and the research on that index is nearing completion. We expect that these two accesses will be in existence by the end of the calendar year. We will add a third access by class number. In other words this index will make it possible to search the file by subject, using the class subject number of whatever classification scheme the library may be using.

So we have in operation now — or as of Monday — the two types of cataloging.

Earlier this week we brought up the union catalog capability of the system so that when a record comes up on the CRT screen, at the bottom of the record is listed the institutional code for the institutions that hold that book. This information enables any institution to know what the resources are throughout Ohio for a particular title, and in another month we intend to have a message switching capability added whereby it will be possible for an institution to request a title in the system from some other institution. At the present time, as you may or may not know, when your librarian goes looking for a book to borrow that he or she does not have in your institution, there is a fishing game that goes on of trying to find out first where it is, and this search occupies a considerable amount of time in terms of days and weeks. The OCLC system reveals exactly where the book is, and by using the terminal communications, one can find out very rapidly, within an hour or so, where there is a copy that is available to be borrowed, either through the mails or by the borrower going to the library to pick it up. And it is, of course, this increase in availability of resources that is the most important aspect of this system that we call shared cataloging.

Now, what about cost? The costs of the Center are somewhat as follows; I say "somewhat" because this is the first year of our operation on line and these are budgeted figures that I am going to give you — not the figures of actual experience. The costs for the central operation, which includes Phil's salary and my salary and our pencils and paper and so forth, is a hundred and thirty-nine thousand dollars. The annual cost of the central computer equipment is a hundred and ninety-six thousand dollars. The terminals are a hundred and fifty-six thousand dollars, ($7,000 being a one-time installation charge), and the telephone lines are a hundred and twenty-nine thousand. The total is six hundred and twenty thousand dollars. We did a series of estimates of probable savings for institutions, using exact data but only salaries for the costs in the institutions though all of the Center's costs. It was assumed that in the course of a year there would be three hundred and fifty thousand titles cataloged using data that was already in the system, and it was further assumed that for that type of cataloging it would be possible to catalog at the rate of six titles an hour. I've already told you that they are operating well above six an hour so that six per hour was a conservatively low assumption. The gross savings as estimated were just over a million dollars; but remember that six hundred and twenty thousand of that million dollars must be transferred to support the Ohio College Library Center, leaving a potential net savings of four hundred thousand dollars.

The assumption that there would be three hundred and fifty thousand titles cataloged per year averages out to fourteen hundred and sixty titles a day. We hoped — it was not an estimate; it wasn't even a guess; it was a hope because we had really no data on which to do anything else than hope — that we would be able to reach this level of fourteen hundred and sixty by the end of the second year. At the present time and for the past two weeks we have been operating at an average of twelve hundred a day, so it is clear that the daily average will reach fourteen sixty well before the end of the second year. In other words, our estimated net savings of four hundred thousand dollars will undoubtedly turn out to be conservatively low. And mind you, all of these costs are assigned just to the cataloging process. The other benefits of the system, such as the union cataloging information, is assumed to cost nothing; it is supported by the cataloging operation. The communication is free; the use of the bibliographic data in the system for purchasing and other applications that users have already thought up are also without charged costs. If we include those costs in the system, if we spread the costs over those other activities, those products, we would certainly have much more than a four-hundred-thousand-dollar estimated net savings.

Those of you who are librarians, and maybe those of you who are not, know that the standard solution in librarianship to something new is more money and more people. Librarians are not accustomed to cutting back positions to accomplish more, so that the matter of getting rid of a million dollars worth of people, which is exactly what these costing figures require, is definitely a new departure. This cut back will be achieved, I trust, by normal attrition in the course of the next two years. In fact, some libraries have already achieved reductions. Some who used the off-line system extensively were able to not fill one or two positions when they became vacant. But there's no doubt that the major problem associated with this kind of a system is not a technical problem but a human problem. It is the problem of replacing people by machines and getting rid of the people. This type of education of staff is not something that we are accustomed to do in academia. Many OCLC institutions did not "know" that the system was going to work, and they were naturally reluctant to not fill positions. I would hope that as other systems like this one start up in other areas, that the OCLC experience will give librarians in the other areas sufficient courage so they can operate more rapidly in terms of divesting themselves of people. Nevertheless, it is going to take time to reduce staffs if individuals are not to be wounded, and techniques will have to be worked out such as the possible technique of OCLC running off-line catalog production for other regional centers before they start with on-line production, thereby providing libraries in other regions with additional time to take advantage of normal attrition.

As for future costs of the system, we are going to need more storage, probably not at a linear rate because we have plans for compression that will enable us to save more space than we do now. We save about twenty percent of space at the present time; that is to say, that the MARC records in the system are reduced to seventy-eight percent of their size as we receive them without any information being lost so that we can regenerate them. But we will need more storage, and this increase in equipment would appear to be a major increase in the present subsystem, a major increase in cost. However, I want to point out some other aspects of cost behavior in mechanization. As for the terminals we will have at the end of three years an eighty percent equity in the terminals so that for about ninety-five thousand dollars, in opposition to the hundred and forty-nine thousand dollars annual leasing cost, we can purchase them outright. Such a purchase will reduce the expense of the center by about twenty-five percent. We can do a similar thing with the modems over about a 15-month period to amortize the purchase of modems and thereby effect about a ten percent reduction in the cost. In the case of the computer, at the end of forty-eight months, we will have accumulated seventy percent equity, and at that time we may elect to purchase the computer with a bank loan extending over much more than the remaining two years of the lease, so that this purchase would further reduce in two steps the cost of the system.

You undoubtedly are raising mental questions about obsolescence concerning the purchase of a Sigma Five four years from now, and it may be that it will turn out to be obsolescent. However, I should point out that there are two events that cause obsolescence: one is that the machine wears out; and the other is that the job wears out. Now, we are quite confident that the machine isn't going to wear out for a decade. Moreover, the machine is part of the system and even if we did get an order of magnitude increase in the speed of machines all we have to do is get a drop to ten percent of present telephone charges in order to take advantage of that increase in speed, and it doesn't seem likely that a 90 percent reduction in telephone charges is going to occur.

Finally, let me say that it is entirely possible that the job may wear out. As you will hear from Phil, we are not mimicking library techniques. We are going in the direction of a major change in librarianship, and that change is to mechanize descriptive cataloging that will be possible to invoke when we have all of the accesses and all of the bibliographic material — cataloging data — converted to machine readable form in the central catalog.

We simulated mechanized descriptive cataloging on the system and found that it runs just a little bit more efficiently than the present system, so we are confident that for ten years neither the machine nor the job is going to wear out. But we are not so confident that we have already purchased it; we are going to wait at least four years before we make that decision.

The major point of mechanized descriptive cataloging is that we are going further down the road in the direction of mechanizing the library process, so that we will have a continuously and increasingly productive technology that will bring library economics into line with the economy of our society as a whole. I am convinced that we in librarianship will achieve economic operation before the rest of academia.

OCLC SYSTEMS: TECHNICAL ASPECTS

by Phillip Long
Ohio College Library Center

Probably our chief trial and tribulation was that those for whom our trials and tribulations were undertaken had little understanding of the trials and tribulations we were undergoing on their behalf. Words that abound in the data-processing/computer science area, like bugs and crashes, have very little meaning in a world of classic and not-so-classic librarianship. There was a constant query, if sometimes unstated, to the general effect of "why was this thing not running yesterday, or the day before, or twenty years ago." This was to be expected; one is deluding himself excessively if, in undertaking such a project he does not expect such.

The first major technical effort we had to undertake was that of selecting the computer. This was quite a problem; it was quite a problem, for one thing, because neither we, nor in general computer manufacturers, had the foggiest notion what a computer well suited to library processing might look like. But, forging ahead nonetheless, we ended up with proposals from some ten or eleven manufacturers for machines of varying "power," with varying price tags. Some had green central processors, and some had purple central processors, and some had excellently designed tape drive cases and other important features. It was not at all clear what the machine — what the characteristics of the machine — ought to be. Moreover, we reached the startling conclusion that manufacturers present data regarding their products in a fashion which is, if I may say so, fiendishly well designed to avoid the possibility of an effective across-the-board comparison. So we cast about for a solution. Fortunately the calluses didn't get too thick on our foreheads before a possible solution came to mind; that, as Fred mentioned earlier, was simulation. We sought out the services of Comress, Inc. in Washington, D.C., a firm which has a very excellent reputation in simulation of computer systems.

As best we could, we defined the Comress people models of the five subsystems, and we defined the machine configurations. This last was not particularly difficult; it came right from the proposals. Then we took the recommended operating systems as proposed and propounded by the manufacturers — that wasn't a great problem — and we started to grind away.

Surprise number one was, as Fred mentioned, that everybody failed. Miserably. There were varying degrees of miserableness — but nobody's machine would do it.

This was a trifle embarrassing; it was, in fact, quite demoralizing. Mike Crawford, the Comress analyst, and I sat back and asked ourselves what might be done. The thought occurred to us that it *might* be possible — that is, we *hoped* it might be possible that the hardware was capable of doing the job. Adopting the view that the only thing you can do with software is make hardware look worse than it is, and that the more glorious your software gets, the worse your hardware looks, we felt that we might be suffering from an excess of glorious software. So we looked through the SCERT simulation program's operating-system factor library, to see if there weren't some common unhappy characteristics having to do specifically with the processing we were attempting

— not the processing every man might attempt, or that the next man might attempt, but something that these operating systems did unnecessarily and across the board. We had to be neutral in this, so we were looking for things that everybody was doing that, in our view, was wrong. We did find five or six such items, and we set about, having announced to the vendors that we were going to do it, the creation of a set of mythical operating systems for these machines which had the characteristic that they did exactly what we wanted to do for this sort of process, in the way we needed to do it, with absolutely minimal degradation of the capabilities of the hardware.

The result of this was that — almost incredibly — virtually across the board, there was a factor of three decrease in the amount of central processing power needed. If a machine previously required three hundred percent of its central processor, then to do the very same load under the mythical operating system, it took a hundred percent.

Well, there were machines which originally took less than three hundred percent; they now needed under one hundred percent; thus there were a small number of machines, the Sigma 5 among them, which ended up in the "winning circle." The winning circle consisted of those machines that, under the full load at the seven-year level of projected usage, took thirty-five percent or less of the central processing and channel facilities to handle the processing. I should also say that, in the process, we discovered ways of improving our model. I can now tell you of dozens and dozens of ways not to put together such a network as this; I can tell you of a very few ways to put one together, so that it will work well.

I should say that it wasn't simulation alone that decided the machinery. The simulation allowed us to see the effect of various things very easily, very quickly. In two or three days we could radically change the nature of the "processing," or the loading, and observe the effect of that change. What "if this . . . or what would happen if . . . ." We were thus easily able to get a feeling for what would happen under a large variety of conditions. We established, by this, a class of machines that were capable of handling our processing. That didn't say anything about other characteristics of the machine, or of the desirability of the machine for others' jobs; other characteristics might be "how well does the manufacturer service this machine" or "what's its price tag?" Incidentally, regarding price — it was the last thing we looked at. It turned out, when we did get around to looking at price tags, that the Sigma 5 was the second lowest cost machine bid. That really blew our minds. We had gone into this effort with the assumption, that, obviously, if you spend enough money, and you get a big enough, powerful enough machine — a Super Whiz-bang Ninety-nine, you could clearly do the work. What we wanted to do was spend the minimum money to get the job done. Well, we found out that on this job, and I tend to suspect on many, many jobs, the correlation between the price tag the manufacturer puts on his equipment and its ability to do your job is *nil*.

Within the guidelines established, by simulation, for operating system programming, we undertook to rewrite the XDS RBM operating system. We did so. We did this through a simple process — we put in our forty hours, and then we left each day.

It's now done; it's working reasonably well; in fact, it's working well enough that one is blinded by the blaze of the wait light on the CPU, with eighty-odd terminals up — no, it's a little less than that — I guess about seventy-five terminals up, at the moment.

The programming applications were undertaken in the same way: Write them quick. Write them once. But write them in such a fashion that our users, the terminal operators get what they want. They are the "customer." Operators are the weakest, most error-prone — if you look at it in a mechanistic sense — peripheral in the system. Anything you do to the operators that makes life miserable for them will result in error rates you don't want; you want to make your operators comfortable. It turned out that it didn't cost a lot more to program in this fashion — it really didn't, and that was a happy event.

We undertook, in parallel with writing this operating system, a rather hefty program of research on file organization. We determined that all the so-called classic, neat ways that people had propounded weren't quite so neat. They look good in a journal, if you're talking about, say, a table of a thousand or ten thousand entries, but when it comes to a million record file on a real live disk, it's a trifle different.

At the same time we were looking at keys — access keys. What sort of a key could a user easily remember with small probability of error that would quickly lead to what he wanted; what he wanted was a *known item*. We devised those keys. We took the minimum length key we could; first, because keying takes a long time; second, because the more you key, the more chances you have of making spelling errors. Well, let's just leave it at that — I'm running out of time. We found a key, the shortest key we could that, better than 99% of the time, would give us less than a screenful of possibilities from which to choose. It was a non-specific key. We knew, from a couple of visits I made to Bell Telephone Laboratories in Holmdel, that an operator, in their case the telephone operator, can very quickly learn to scan a choice list — this minimizes time to access the desired item.

ERIC

OHIO STATE UNIVERSITY LIBRARIES SYSTEMS

by Gerry D. Guthrie
Ohio State University Libraries

Today I will discuss with you some of the aspects of our on-line remote catalog access and circulation control system.

The automated circulation system began full operation in November, 1970. The system accommodates over 850,000 titles representing 2.5 million physical volumes of the OSU Library collection. It services 25 separate terminal locations utilizing 11 cathode ray tube terminals and 33 typewriter terminals. All terminals are connected to a central computer via a telephone line network. The circulation for the last record year was 1.5 million.

The system can be conceptualized as two separate and distinct units. The first unit handles the traditional problems of circulation control. The circulation control unit will charge and discharge books, keep records of books in circulation, put saves on books, record statistics, send notices, etc. This has been the traditional approach to library automation in the past, i.e., to perform on a computer those activities that were previously done in the manual system. This is indeed necessary and the OSU system provides for all the aspects of traditional circulation control.

The second unit of the system provides remote catalog access to the libraries' holdings. This aspect of the OSU system is truly unique.

We wanted to set up a system which would provide a new and valuable service for a significant portion of our users. A study at a large research library conducted recently showed that over 70% of patrons using the catalog are searching for specific known items. With this as a basic assumption, we derived a search key for known items which is composed of the first four characters of the author's last name and the first five characters of the first significant word of the title. Thus we may search our entire file by author and title. The search key is similar to the search key used by the Ohio College Library Center, however, their key uses only three characters of author and title.

In the interests of brevity I will not discuss the aspects of circulation control. I will just describe in general how the remote catalog access works.

A telephone center is located at the Main Library containing six cathode ray tube terminals. Seated at the terminals are six telephone operators with telephone headsets. The patron, desiring library materials, telephones the center. He calls from his college office, dormitory, or anywhere a telephone is available. Our only restriction is that we will not accept collect long distance calls.

The patron asks for a specific item by author and title. The operator transfers this information to the computer by creating the search key which she then enters via the keyboard. All items in the collection matching that particular search key are displayed on the terminal screen. The operator identifies the specific title requested and keys in a request for the detailed holdings for that particular title. The next display shows the number of volumes, number of copies, specific locations, and the circulation status of each. The circulation status indicates if the books are in circulation, who they are charged to, when they were charged, when they are due, and other information for special charges.

If copies are available, the operator relays this information to the patron and he selects the copy he wants. The patron then gives the operator his patron identification number and the operator charges the book to the patron. The charge updates the circulation file instantaneously and the charge information will be available to the next person accessing that title. The computer transmits a message to the Main Library or one of our 22 department libraries and prints on a typewriter terminal. This message is called a "pick slip." The pick slip contains call number, author, title, holdings, and patron identification. The librarian in the holding library will then pull the pick slip from the terminal and retrieve the book.

At this point, there are two options. If the patron wishes to come into the library to retrieve the book, the book is placed on a hold shelf. However, if the patron wishes to have the book mailed to him, the librarian will place the book in a campus mail envelope and use the pick slip as a mailing label. The campus mail system will then deliver the book to the dormitory or office of the patron requesting it.

For the library user, we have added a new dimension in library services. The user may simply pick up his telephone, request a book, and have it delivered to him the next day. We have found that the major delay in the system has been in campus mail service.

The remote catalog access portion of the system is an effective use of a combination of computer files, on-line terminals and telephones to provide technologically enhanced library services. A study was performed prior to the implementation of the circulation system to show the potential savings that could be realized in patron time and money. For the purposes of the study, we selected only faculty circulation statistics, an estimate of the average distance that the faculty member would have to tra the average faculty salary, an estimate of the number of trips wasted because the book was already charged out, an average walking speed of two and a half miles per hour, etc. The potential savings in faculty time alone would represent over $1,000,000 in salary per year. It would be an interesting exercise to try to get these savings added to the library budget for next year.

The Ohio State University circulation system is primarily user oriented. It not only accommodates traditional circulation control but also provides a useful time saving remote catalog access.

DISCUSSION: OCLC SYSTEMS

QUESTION: What was the time in terms of manpower to complete your work at OCLC?

MR. LONG: Well, that's a very difficult thing to answer. About the on-line system, as such, I can say the following: There are essentially three elements in the on-line system, *per se*. There's the root of the monitor; there's a package which is lovingly called MOTHERHOOD; and there's the package called CAT. The root of the monitor provides the basic scheduling services of the machine and basic I/O handling, error correcting, so forth, and so on, and provides the device drivers. I wrote that. MOTHERHOOD concerns herself with tasking and sub-tasking and file management. A fellow by the name of Al Landgraf wrote that. CAT is the on-line program which actually handles the matter, the very complex matter, of the cataloging applicating. John Wyckoff wrote that. We did it in a year.

MR. KILGOUR: The total grants that were made available were ninety thousand dollars from the Office of Education, fourteen thousand dollars from the Council on Library Resources, eighteen thousand dollars of LSCA money, four thousand dollars and seventeen hundred dollars from the National Agricultural Library. In other words, we're nickles and dimes operators.

MR. LONG: We're not-for-profit, and it was never a problem to worry about what to do with a profit. I should say that we didn't start from scratch; we had gone through the exercise of putting together an off-line system at that point, so we were not without experience, and we were not without direction.

MR. KILGOUR: Yes, Phil has been on the staff for two and a half years and the others for a year and a half, so it isn't a tremendously long time.

MR. LONG: Other questions?

MR. KILGOUR: Yes, here's another question.

QUESTION: What is the expected maximum terminal load of the system?

MR. LONG: I don't know; I can't count that high on the fingers at the moment. In the first place, there is no simple answer, a priori, to that. It depends, for one thing, on the mix of activities. Cataloging put one sort of load on the machine, circulation puts another on a radically different nature, so forth and so on. I can say the following: we've got seventy or so terminals sitting out there today, on-line, and cataloging. All indications are from observations we've taken of that machine, that, for cataloging, we could probably put ten times that many terminals on that machine, and handle them nicely. You can't see the wait light go out. All code is written in assembler language; all the applications are just as efficient as the operating system, and for a change, the operating system is efficient. All the code is reentrant; there is no fat. The whole system, i.e., the operating system, the root of the monitor, MOTHERHOOD, and the cataloging application, and all buffer space necessary to run these seventy terminals runs in a 128K-byte chunk of core. In fact, it's a little bit less than 128K.

QUESTION: What speed do your telephone lines have?

MR. LONG: Three hundred characters per second, twenty-four hundred bit per second synchronous transmission, full duplex. That *synchronous* is crucially important, and the fact that the terminals are operating in message mode, instead of character mode is also crucially important. We get one interrupt for a six hundred character message, and not six hundred.

QUESTION: How can an individual college become a user of your services?

MR. LONG: As was indicated earlier, we cannot and do not serve other than our Member colleges. We do and have undertaken cooperative efforts with other centers within which we have provided services to their constituents.

Chapter 6

Information: Indispensable Management Resource

INFORMATION: INDISPENSABLE MANAGEMENT RESOURCE

by John D. Millett, Chancellor
Ohio Board of Regents

I would like to add my word of welcome to that which you have already received from President Fawcett. In particular, I would welcome you to the wonderful world of Ohio, where as of this evening we are completing our 106th day without a state government budget for the biennium which began last July 1st. It is obvious that the old idea about the indispensability of budgeting is another one of those concepts no longer relevant to the new technitronic age. Your visit to this state will not have been in vain if you acquire this one lesson.

I suppose that at this point I should pause to make an obvious comment which unfortunately is so obvious that it is frequently overlooked. All the information in the world is no substitute for decision-making. Perhaps, I should be even more emphatic and put the proposition this way. The capacity to decide is the essential ingredient of any action system. The capacity to decide may be reinforced through information. Decisions may be made more acceptable when based upon convincing factual data. But information will not and cannot replace value judgments, and the act of valuing is still a major factor in the art of decision-making.

In a long career in public administration which now spans 35 years, I have been a constant advocate and user of information. When I was first exposed to the planning process of the Executive Office of the President before World War II, I discovered the extent to which essential data were so often unavailable as needed for decisions about the utilization of water resources, about the impact of public works activity upon employment and economic expansion, and about the cost of community facilities required to support new production plant.

When I was an army officer in the office of the Commanding General, Army Service Forces, in the Pentagon, I obtained a liberal education in the use of statistical information, both in the establishment of performance objectives and in the measurement of performance output. Interestingly enough, although the War Department of the United States had been largely dismantled during the years 1920 to 1940, those years supposedly made safe for democracy by the glorious victory of 1918, the statistical techniques advocated by Leonard Ayres in 1917-18 were not completely forgotten. The Army Service Forces under its able commanding general, General Brehon B. Somervell, was able to perform its logistical mission as effectively as it did in large part because of the information base upon which it operated. If there were tensions between the War Production Board and the ASF in the years from 1942 through 1945, as there were, these conflicts arose in considerable degree because the urgency postulated by available data was interpreted in differing ways.

In 1949 not long after the end of World War II, I became involved in the analysis of the operations of higher education, an enterprise from which I have not yet escaped. One of my first acts as a research director was to hunt up my colleague Frederick Croxton at Columbia University and seek his assistance in recruiting a statistician who would be imaginative enough to be an analyst and interpreter of extensive, yet fragmentary, data. I was fortunate beyond my desserts in the young Ph.D. Fred Croxton found for me, and our association was a profitable one, indeed. Subsequently, my colleague in this endeavor became chief statistician for Time, Inc. But the Commission on Financing Higher Education in 1952 published the most extensive set of statistical data about American higher education which had been provided up to that time.

I could continue in this reminiscent vein about the intervening 20 years as a university president and as a chief state higher education officer. It is sufficient to comment that throughout these years I have found management information an indispensable technique in the operation of a single public university and of an entire state system of higher education.

Perhaps it would be most useful to you if I undertake in the time available here this evening to review with you some three areas of operation in which an adequate data base is the very essence of higher education operation. In this process perhaps I can also illustrate the needs which still exist for even greater efforts on our part to obtain more exact information essential to the planning process in higher education.

It is unnecessary to observe here the importance of enrollment data. All of us are constantly making use of available information about the students enrolled in higher education. That there are major deficiencies in these data is also obvious. Here in Ohio in our Uniform Information System, we have systematically collected an extensive array of student data, perhaps more data than immediately needed for decision-making. But one can never tell when some particular kind of information will become vital.

For example, a few years ago when the draft deferment status of graduate students was terminated by Act of Congress, we here in Ohio, as elsewhere, were confronted suddenly with the need to know the age of all our graduate students. Graduate deans were certain that the end of draft deferment would have a disastrous effect upon graduate enrollments. Fortunately, here in Ohio through our uniform information system it was possible for us to know immediately that two-thirds of all our male graduate and graduate professional students were over 26 years of age. The predictions of catastrophe were quickly dispelled by an ascertainable fact.

The particular enrollment data I wish to refer to tonight have to do with the distribution of enrollment between the private and public sectors of higher education. Our experience in Ohio in this respect is representative of the experience throughout the United States. As recently as 1960 on an autumn headcount basis the private colleges and universities in this state enrolled about 80,000 students, or 45 percent of the total Ohio enrollment. Last year, in 1970, these private colleges enrolled almost 95,000 students, but this number as a proportion of total enrollment had fallen to 25 percent. Moreover, in 1969 and 1970 total enrollment in private colleges and universities declined from the level of the preceding year, and this loss was not occasioned by the absorption of any private college into the public system.

I notice in a recent volume of the Carnegie Commission on Higher Education, the study by Harold L. Hodgkinson entitled *Institutions in Transition*, this "major conclusion": "The huge increase in college students has been handled through the public sector, by building many new community colleges and by expanding existing public colleges and universities, often to enormous size." This observation is as applicable to Ohio as it is to the United States as a whole.

In 1960 the public institutions of higher education in Ohio enrolled 96,000 students on an autumn headcount basis. In the autumn of 1970 this enrollment had increased to 280,000 students, a growth of three times or of 200 percent. There are several qualifications which could be made in these data, but the stark fact still remains that the enrollment expansion in Ohio as in the United States during the 1960's was accommodated by the public sector of higher education. Without that effort, far fewer youth of college age would be enrolled in higher education today. These youth may not like the large size, the anonymity, the ponderous response to demands for change on the part of our public universities, but I wish once in a while someone would acknowledge that public higher education did rise to the challenge of numbers and did meet this demand for educational opportunity.

Now we face a new situation. The private colleges and universities in considerable numbers face a dismal future. It does us in public higher education little good to suggest that the complications of that future may have been created by their own actions. Regardless of causes, private colleges and universities confront a stable or declining enrollment with continuing pressures for increased costs of operation. How does American society respond to this new situation?

One factor in the diagnosis of the current plight of private higher education is the matter of charges to students. Even though our instructional charges to students here in Ohio tend to be relatively high in comparison with the charges of public institutions in other states, our charges are substantially less than those in most private colleges. This current academic year our instructional charges at public universities are $750 for a three-quarter academic year. There are some 20 private colleges and universities in Ohio where the tuition charge for one year is currently between $2,000 and $3,000. There are another 20 or so private colleges and universities where the tuition charges are from $1,200 to $2,000 this year. With some exceptions, it is my observation that it is the private colleges whose charges are under $2,000 which tend to feel the enrollment impact of the $750 public charge.

Actually, we don't know the extent to which the differential charge between public and private higher education provides a positive economic inducement for students to enroll in public higher education. Is this difference in charges to students the major force which affect the enrollment of private higher education? Would a substantial increase in charges to students at public institutions change enrollment trends? Is this kind of action the principal action needed to alter a growing disparity in enrollment trends?

I wish to suggest that some very important policy decisions are going to be made in the near future on this whole subject, and I submit we have at the present time very little factual information upon which to base those decisions. It is high time we devoted some careful attention and some careful fact-gathering to this whole subject of the place of private higher education in the total higher education endeavor in this country, and to the whole subject of how that place can be preserved and strengthened.

Now let me turn to a second subject, budgeting for higher education. The other day I read an interview with a new university president. Since the interview consisted of questions written out by the reporter and of answers written out by the president, I assume for a change that the president was correctly quoted. In this interview the president had some disparaging remarks to make about work load data and expenditure formulas in the preparation of university budgets. He did not indicate his alternative, but I could not help wondering how a university budget was going to be constructed without work load data and some standard of required expenditures. To me the alternative is clear: the subjective judgment of the administrator. And the day when a president of a university could play the all-knowing, all powerful, father-knows-best kind of executive has long-since disappeared.

I am thoroughly familiar with all the faculty arguments about how different their work load is from that of any other professional practitioner and about how there are no fixed standards for the faculty work week. I am well aware that faculty members perform a variety of professional tasks: instruction, administration, research, and public service. I am well aware that the instructional work of a faculty member may be at different program levels: the associate degree level, the baccalaureate level, the master's degree level, and the doctoral degree level. I am well aware that the instructional work of a faculty member consists of more than classroom lectures or discussions and more than laboratory demonstrations or supervision; that the instructional work consists of student advising, student evaluation, extensive reading in the field, some research or creative activity, classroom and laboratory preparation, reading of student papers, attendance at scholarly meetings, and participation in curriculum development. I am well aware that many studies of actual faculty work activity reveal average work weeks in excess of 60 hours.

I am well aware of all these facts because I have been a faculty member as well as a university administrator and a state government official. But as a university administrator and as a state government official, I am also only too well aware that the general public, including the student public, does not understand the nature of faculty work nor the length of the faculty work week. The professional practitioner who keeps regular office hours, the skilled craftsman and the production worker who have a fixed forty hour work week, the sales clerk and the service worker and the office worker with a definite place of work and a definite schedule of work — none of these persons can or do understand the faculty work load. And when faculty members depend so heavily for income as they do upon charges to students and upon gifts or taxes from the general public, I am astounded that faculty members generally give so little attention to cultivating this understanding.

But be these comments as they may, I reassert the proposition that the university administrator and the state government higher education official must have some definite standards of expected faculty work performance if he is to defend a higher education budget from its many critics. And let me add from experience that within a single university there are always critics of the university budget, those who think some other department or some other faculty member is receiving favored treatment. When the administrator moves from a single campus to a multi-campus situation, the use of budget formulas is imperative if the equitable treatment of all institutions in like circumstances is to be an objective of administrative decision-making.

I wish there were time here this evening to describe in considerable detail the budget practice and procedure which we have developed here in Ohio over the past eight years. I am, of course, scarcely an objective witness on this score, but I happen to think that we have achieved a remarkably fair and remarkably sensitive budget process for public higher education. This process is described in some detail in a publication of the Ohio Board of Regents and is available to you who may wish to study it.

There are two general observations and one illustration which I should like to set forth about our budget process. The first observation is just this. Our budget effort depends for its effectiveness upon the availability of extensive and comparable data from all the public institutions of higher education in this state. Little by little we have been able to obtain such data and to analyze the data through a carefully programmed computer tabulation. No matter how careful the planning and how widespread the consultation, comparable data among diverse institutions about student enrollments, faculty resources, plant resources, and expenditure patterns will not be obtained in one year or in two years. We have been working at the effort for several years, and we are just beginning to have some confidence in our results.

A second observation should be obvious. I don't care how perfect the budget process, the procedure is no guarantee of adequate financing. Adequacy is at best a subjective judgment. Moreover, all of us know that budgeting tends to be incremental in the provision of additional resources. Incidentally, how many of us understand that incremental additions to a budget of an enterprise is only possible in a society which believes in and achieves progress and growth? But the objectives of Ohio budget practice were not determined primarily in terms of adequacy. If that were the goal, and measured by standards of comparison with other states, our budget practice would then be judged a failure. Our objectives have been two-fold: to treat nearly 60 different campuses on an equitable basis and to recognize that different instructional programs entail different expenditure requirements. I submit that these two objectives can only be met by a carefully determined budget procedure which does postulate standards of faculty work load, faculty supporting services, and institutional overhead.

As an illustration of my thesis, let me cite this example. I often hear it said or I read in mass media of communication that a two-year college costs less to operate than a university. This is a correct statement of fact only in terms of a *gross* oversimplification of institutional differences. For example, I know from our expenditure analysis that a university branch last year on the average spent one thousand dollars per full-time student, while our state universities on the average spent 1,700 dollars per full-time student. These data do not mean that branches were cheaper to operate than state universities. An analysis of expenditures on an instructional program basis revealed that our state universities spent *less* per student in the first two years than branches spent for the same program. Universities spent more per student on the average because their program objectives were so different from those of a two-year university branch.

Indeed, no gross comparisons of expenditure or any other data among institutions of higher education can ever be meaningful unless those comparisons are made on a program basis. That is the message, a perfectly obvious message, of our own budget procedure as we have developed it here in Ohio.

In the third place, I want to say a few words about space standards and space utilization. Public higher education in the United States has been through an unparalleled period of growth in its capital plant facilities during the past ten years. Here in Ohio we figure that since 1964 this state has invested more dollars in the physical plant of higher education than in all the years from 1803 to 1964. I am sure other states could well make the same claim. And I am referring only to state dollars invested in higher education plant; I am not including either federal government dollars or borrowed dollars from the sale of revenue bonds.

And yet in spite of this immense investment, there is not a single public institution of higher education in Ohio which does not assert that it has today some urgent unfilled needs for additional capital plant. It would seem that the more we provide, the more we need in capital facilities. And you have not encountered the quintessence of these needs until you have tried to build a new medical college or to expand an existing one!

Once again the problem of the state administrator as well as of the campus administrator is not to list unfilled needs but to determine the relative urgency of various needs, to establish priorities among needs. I do not wish to suggest that adequate information is the sole requisite for determining the relationship among plant needs, but I do insist that adequate information is an essential first step in trying to establish priorities.

Here in Ohio our space data embrace three primary areas of information: (1) an inventory of space resources; (2) an evaluation of inventory quality; and (3) a record of space utilization. In turn, these data provide the Ohio Board of Regents with guidelines as the basis for determining the future space requirements for each state-assisted institution of higher education.

The space inventory is calculated according to square foot of floor space; divided into gross square footage and net assignable square footage. As of the autumn of 1970 here in Ohio, our state-assisted institutions of higher education had a total inventory of 47.6 million square feet of floor space. Of this gross area, 65.6 percent was reported as net assignable. In our space planning and in our evaluation of space planning by individual institutions, we have a standard that 62.5 percent of the space in any facility should be available as net assignable space, space that is available for the primary function of the facility. We also express this standard as a ratio of gross space to net assignable space of 1.6 to 1.

The space inventory is divided into some ten categories according to major use. Here I shall summarize the data under six headings. We find in our inventory that our gross square foot area is utilized for the following primary purposes:

Instruction	40%
Student Residence and Activities	36%
Library	5%
Research and Special Purpose	7%
Medical	1%
Supporting Operations	11%
	100%

At best these categories create some difficulties in definition, and the dividing line between categories is likely to be interpreted somewhat differently from one campus to another. The distribution of space by primary purpose will, of course, vary from campus to campus. A campus enrolling commuting students will have a limited inventory of space devoted to student residence and student activities. A two-year campus will have very little space devoted to research and special purpose activities. What I have set forth here is a composite of the space distribution at Ohio's public institutions of higher education.

Insofar as the quality of space is concerned, we have employed three ratings: satisfactory, poor, and obsolete. As of last autumn, 86 percent of all our space was rated as satisfactory, 11 percent as poor, and 3 percent as obsolete. Since so much of the space inventory has been constructed in the past ten years, these quality ratings are not surprising. Indeed, our two-year campuses report that over 96 percent of their space is in satisfactory condition. The record would be 100 percent were it not for the temporary facilities which some of our two-year campuses continue to operate until current construction programs are completed.

Space utilization continues to be one of the major challenges for higher education. The Ohio Board of Regents has set up utilization standards for instructional space which I can only characterize as modest. We base our standards upon a forty-hour week, which would require a five day per week, 8:00 a.m. to 4:00 p.m. use. For classrooms our standard is a 30 hour per week utilization, and last year we were able to obtain only a 21 hour per week utilization or just about 67 percent of our standard. We divide laboratory space into instructional laboratories and advanced laboratories, and have set 20 hours a week as our standard of use for instructional laboratories. We were able to realize only a 9 hour average utilization of instructional laboratories. Most of our two-year compuses had a 15 hour use of laboratories per week, but our universities achieved an average use of only half of this.

Data about space is interesting information to possess. Such data are also essential to space management. But the Ohio Board of Regents is not a management agency. As a planning agency space data are essential to the Board in determining future space requirements and in setting forth capital improvement needs. Apart from the needs arising from replacement of obsolete space and the renovation or replacement of unsatisfactory space, our problem is that of determining additional space requirements over a six-year period of time.

Our planning procedure has been, first of all, to fix a standard space requirement per full-time *day-time* student. I say day-time because capital plant expense, unlike current operating expense, depends not upon total enrollment but upon enrollment in the 8 hour per day period of maximum plant use. Upon the basis of the prevailing space inventory in Ohio and of the utilization standards we have established, we have arrived at a standard space need of 75 square feet per day-time FTE of net assignable space. For the University of Cincinnati we have fixed this standard at 80 square feet, and for The Ohio State University we have fixed this standard at 90 square feet. We have omitted all medical school or medical center space from these calculations. Medical schools, and medical education costs, are a law unto themselves, as any university and government administrator has found out to his sorrow.

The second step is to arrive at a projection of enrollment ten years in advance. Because of lead-time factors, space planning over a six-year period must look at least ten years into the future. A multiplication of space standards by enrollment provides a net assignable space objective. The space objective minus the space inventory sets forth the additional net space construction which should be undertaken over a six-year period. Our capital improvement plans are presented to the Governor and the General Assembly upon this basis.

There are many other illustrations which I might provide to emphasize the importance of uniform information on a timely and comprehensive basis. Management and planning are impossible, I believe, without adequate data about operations and about future expectations.

I wish I could say that, given adequate data, management and planning are a science in which subjective judgment and the force of circumstances have no part. But, of course, the truth is that management and planning are far indeed from being a science. Judgment is still indispensable in management and planning. And the best laid plans of mice and men may still go astray when buffeted by the winds of chance.

But management and planning cannot be performed with any reasonable prospect of accomplishment without adequate data. Otherwise, management and planning become completely subjective, completely based upon chance. We have no choice as rational human beings except to accept management and planning as both science and art, to hope that the element of science will become ever more reliable, and to build our information structure as the basis for our reasonable anticipation of the future.

Supplements

Program Committee

JAMES McKENNEY, Chairman
Harvard Graduate School of Business Administration

MARTIN GREENBERGER
The Johns Hopkins University

FREDERICK KILGOUR
The Ohio College Library Center

JOHN LUBIN
University of Pennsylvania

Host Institutions

The Ohio State University
The Ohio College Library Center

EDUCOM

Fall 1971 Council Meeting and Conference

Computing in Higher Education: Successes and Prospects

Schedule — Panels and Discussion Groups

THURSDAY, OCTOBER 14

Opening Remarks

Henry Chauncey
President
EDUCOM

Novice Fawcett
President
The Ohio State University

Panel Discussion

COMPUTER TECHNOLOGY: RECENT ADVANCES IN THE STATE OF THE ART

Chairman:
Robert Taylor
Principal Scientist
Xerox Palo Alto Research Center

Peter Lykos
Program Director
Office of Computing Activities
National Science Foundation

Robert Rapp
Associate Head of Physical Sciences Department
Rand Corporation

Barry Wessler
Computer Science Department
University of Utah

Panel Discussion

COMPUTER SYSTEMS FOR UNIVERSITY PLANNING

Chairman:
James McKenney
Professor of Business Administration
Harvard Graduate School of Business Administration

George Turner
Center for Research in Management Science
University of California at Berkeley

Ben Lawrence
Associate Director
Western Interstate Commission for Higher Education

Ronald Brady
Vice Chancellor for Administration
Syracuse University

Group Discussions

A MINI-COMPUTER TO PROVIDE LOCAL COMPUTING AND ACCESS TO A NETWORK	Chairman: **Peter Lykos** Program Director Office of Computing Activities National Science Foundation
USING THE NETWORK TO SELECT THE APPROPRIATE COMPUTER FOR YOUR PROBLEM	Chairman: **Robert Rapp** Associate Head of Physical Sciences Dept. Rand Corporation
USES OF THE TRILLION BIT MEMORY	Chairman: **Barry Wessler** Computer Science Department University of Utah
WHY A COMPUTER CENTER	Chairman: **Robert Taylor** Principal Scientist Xerox Palo Alto Research Center
DEVELOPING PLANNING GUIDELINES IN A LARGE UNIVERSITY	Chairman: **Frederick Balderston** Chairman, Center for Research in Management Science University of California at Berkeley
MANAGEMENT CONTROL IN THE UNIVERSITY	Chairman: **Robert Anthony** Professor of Business Administration Harvard Graduate School of Business Administration
AVAILABLE PLANNING METHODS FOR UNIVERSITIES AND COLLEGES	Chairman: **Ben Lawrence** Associate Director Western Interstate Commission for Higher Education
INNOVATIVE PROSPECTS IN COMPUTING	Chairman: **Ronald Brady** Vice Chancellor for Administration Syracuse University

Panel Discussion

SUCCESSFUL COMPUTING SYSTEMS: INSTRUCTION, RESEARCH, AND ADMINISTRATION

Chairman
Larry Stolurow
Director of Graduate Studies & Chairman
Department of Education
SUNY, Stony Brook

Wilson Judd
Associate Director
CAI Laboratory
University of Texas

Rex Krueger
Director
Computing Center
University of Colorado

Donald Bitzer
Director, Computer-Based Education Research Laboratory
University of Illinois

Michael Hall
Consultant
Auerbach Associates

Banquet

Address
DR. JOHN D. MILLETT
Ohio Board of Regents

FRIDAY, OCTOBER 15

Presentation and Discussion

LIBRARY SYSTEMS: INCREASING RESOURCES AND DECREASING EXPENSES

Chairman:
Frederick Kilgour
Director
Ohio College Library Center

Gerry D. Guthrie
Head
Research and Development
Ohio State University Libraries

Philip L. Long
Head
Research and Development
Ohio College Library Center

Group Discussions

THE OHIO STATE UNIVERSITY MECHANIZED INFORMATION CENTER

Chairman: **Gerald J. Lazorick**
Director
OSU Mechanized Information Center
The Ohio State University

OHIO COLLEGE LIBRARY CENTER CATALOGING SYSTEM

Chairman: **Frederick Kilgour**
Director
Ohio College Library Center

REMOTE CATALOGING ACCESS AND CIRCULATION CONTROL SYSTEMS AT THE OHIO STATE UNIVERSITY

Chairman: **Hugh C. Atkinson**
Director
The Ohio State University Libraries

COMPUTER ASSISTED INSTRUCTION AT OHIO STATE UNIVERSITY COLLEGE OF MEDICINE

Chairman: **Gregory L. Trzebiatowski**
Assistant Dean
Ohio State University College of Medicine

THE PLATO SYSTEM AND COMPUTER-BASED EDUCATION

Chairman: **Donald Bitzer**
Director, Computer-Based Education Research Laboratory
University of Illinois

MANAGING A COMPUTER CENTER AS AN INDEPENDENT ORGANIZATION

Chairman: **Rex Krueger**
Director, Computing Center
University of Colorado

EDUCOM FALL COUNCIL MEETING
Columbus, Ohio
October 13-15, 1971

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