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ABSTRACT

Business and management study programs are making increasing but still limited use of computer-assisted instruction (CAI) as an instructional tool. The cost of course development and design for business and management instruction is high, but declining hardware costs and increasing use will lower per student hour costs. CAI is now used primarily for drill and practice in mathematics, word usage, and technical skills. Only recently has it been used in complex situations involving education and business theory. Limitations in the successful application of CAI to curriculum development are due to distrust of and lack of confidence in the computer and skepticism regarding the instructional capability of any automated teaching technique. A survey of schools of business administration and management revealed that such programs now use CAI for about 5 percent of instruction. They are expected to increase their use in the next ten years to about 20 percent. (CH)

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COMPUTER ASSISTED INSTRUCTION FOR MANAGEMENT AND BUSINESS STUDY: A LOOK TO THE FUTURE

by

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CHAPTER I

INTRODUCTION

> Computer-assisted instruction will surely come into general use in the schools, probably within the next decade, and possibly before either the schools or manufacturers of CAI systems can ensure its wise use.[1]

This statement raises two important questions concerning the field of Computer Assisted Instruction (CAI): Can it become universal in its application to teaching, and how effective will it be? Some authorities feel that computers in general have been overemphasized and that CAI is just a temporary fad which will not have a major effect upon education. Because of this opinion the computer industry has developed a cautious attitude about producing CAI hardware.[2] There is no doubt that an examination of many existing systems will confirm that they are much less sophisticated than certain proponents of CAI would admit. And yet, "Truly rich and sophisticated environments...are practical and possible with a

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[1]Bruce L. Hicks and S. Hunka, The Teacher and the Computer (Philadelphia: W. B. Saunders Co., 1972), p. 21.

[2]Allen L. Hammond, "Computer-Assisted Instruction: Many Efforts, Mixed Results," Science 176 (June 1972):1006.

computer."[1] To evaluate the potential of CAI an examination will be made of its development and of some applications which have been recently created.

What is known today as Computer Assisted Instruction (CAI) is an advancement of rather simple programmed instruction courses first developed in the 1960's. The concept of using automatic learning tools extends back as far as the 1920's, and by 1936 nearly 700 teaching machines had been patented in the United States.[2] Initially, the techniques used were not very sophisticated and the subject material offered covered only those areas where rote memory or repetition would be the alternative "instructive" methodology. Eventually the developers of this instructional technique began to use the computer and its programming capability to assist not only in the process of material presentation and feedback, but more importantly in the expansion of the learning potential offered the student.

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[1]Stuart Milner and A. M. Wildberger, "How Should Computers Be Used in Learning?," Journal of Computer-Based Instruction (August 1974):10.

[2]Gordon Pask, An Approach to Cybernetics (New York: Harper and Bros., 1961), p. 88.

During the last ten years, many American universities have sponsored the development of CAI programs in attempting to discover more of the potential benefits this technique might offer. The results could alter some of the most traditional beliefs about educational methodology.[1] As a result of these efforts, some institutions today offer standard courses which become individually unique as a person interacts with them. The intellectual challenge offered is far greater than was imagined even by proponents of automated instruction only a decade ago.

Rapid technological advancement in two pertinent fields have contributed to the increased use of CAI. The first is the extension of computer power itself, in terms of size, speed and cost. Vastly increased memory capacities have enabled more complex program development. The simultaneous advances in circuitry have reduced greatly the processing times for these larger programs. Reduced cost per operation for this hardware has enabled the undertaking of CAI program development which previously would have been too costly to consider.[2]

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[1]Roger E. Levien, The Emerging Technology (New York: McGraw-Hill, 1972), p. 127.

[2]Hicks and Hunka, The Teacher and the Computer, p. 20.

The second field, equally as important, is that of the remote terminal and the associated telecommunication hardware and software technology. Development in this area has been essential to the successful growth of CAI. It has enabled a central computer to serve many students at remote sites simultaneously.[1]

These combined technical developments have motivated American educators to begin to develop a wider variety of CAI applications. Assisted primarily by the endowment of federal funds, the university has been the center of research in CAI.[2]

Among the subject areas for which CAI applications have been developed are those associated with the field of business administration and management. The earliest courses in this field to use computer assistance were business statistics and economics. Program logic was limited to linear or branching techniques based upon specific factual response to questions or problems. In this sense, CAI applications in business subjects kept pace with the state of the art.

As time passed, the business field became the subject of a new level of computer instruction, so-called "event processing." In this technique, computer symbols

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[1]Ibid.

[2]Levien, The Emerging Technology, p. 165.

are used to represent real-world phenomena and students then interact with and respond to these phenomena to test out various patterns of action. This process is known as computer gaming.[1] The use of a simulated environment enables students to develop personal strategies and to test out their business and managerial decision-making sense.

This gaming process is an excellent example of a cybernetic system of communication, feedback and control. In his classic work Cybernetics, Norbert Wiener addresses this aspect of man-machine interface and postulates that man-made machines can learn.[2] This theory introduces one of the most fascinating aspects of CAI development: that of adaptive computer program response. In this kind of program the responses are not defined in advance but rather are developed in accordance with the individual response patterns of the student.

Research Question and Subsidiary Questions

The curriculum for university business schools has been greatly expanded in recent years. This expansion has resulted from the increasing complexity of a manager's

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[1] Ibid., p. 25.

[2] Norbert Wiener, Cybernetics, revised ed. (Cambridge, Mass.: M.I.T. Press, 1962), p. 10.

role in today's business firm or government agency. It is essential for students of management and business to have a sound business education which provides them with a working knowledge of several fields including human behavior, organizational theory, finance, personnel and electronic data processing (EDP). This is especially true of graduate business students preparing for some specified professional career field.

Managers who have not had the benefit of a prior formal education could also benefit from a career development plan which would include formal courses in the above subject areas. Such career plans would enable the businessman and manager to add conceptual knowledge to their work experience and also to take some selected refresher courses even if they have had some prior education.

It appears that CAI might be a useful technique in the development of courses for business curricula in universities and for career development in business and government. A number of business schools currently use CAI in their curriculum: e.g., University of California at Ervine, Stanford, Illinois, Massachusetts Institute of Technology, State University of New York, Harvard and Texas. Most of the courses currently being offered through

CAI are those where precise subject-matter definition is possible such as business mathematics, statistics, economic formula application and computer science. Relatively few CAI systems involve the more abstract business curriculum courses of behavioral theory, organizational concepts and decision-making analysis.

There has been more extensive research and progress, however, for CAI development in other non-business-related fields involving more abstract subjects. These include medical diagnostic courses using the dialogue method in CAI, heuristic games like chess and bridge, and fine arts such as music and poetry. These last applications are not a part of CAI technology as such, but do involve computer program definition and interactive dialogue between human and computer.

Because of such recent developments it seems that there is great potential for the use of CAI techniques in business and management courses. This leads to the basic research question of this thesis:

To what extent will Computer Assisted Instruction (CAI) be used in teaching business and managerial courses at the university and professional level during the next five to ten years?

In attempting to address this primary question, several subsidiary questions will be raised:

1. What have been the major trends in the development of CAI, both in concept and technique?

2. What are the major areas to which CAI has thus far been applied?

3. What psychological factors are involved in the preparation of CAI courses, and in their usage by students?

4. What are some limitations encountered in developing and offering CAI programs in general?

5. What are trends in computer hardware and terminal design, and what effect will these factors have on CAI usage in the future?

6. To what extent has CAI been effectively used in business and managerial study to date?

Purpose and Scope of the Study

The objective of this thesis is to explore the feasibility of developing and using CAI techniques for business and management subjects in the near future. Conclusions and answers to the research questions have been based upon examination of the literature on recent developments in CAI, and on the opinions expressed by authorities in the field about its potential.

In performing this study, an examination has been made of the history of CAI development and of the pertinent terminology unique to this field. Significant terms are defined in the Appendix to the thesis. Psychological aspects of CAI program design have been examined since an understanding of these principles is essential to successful design of CAI business courses. Considerations in selecting computer hardware and remote terminals were examined since they affect the cost and availability of CAI courses for both students and practicioners of business. Technical details of hardware and terminals were addressed only to the extent that they pertain to CAI course design or presentation.

The subjects under consideration include those which might be contained in the curriculum of a university business school, such as: accounting, economics, marketing, computer science, personnel administration, human behavioral theory, statistics, commercial law, international finance, organizational theory and managerial decision-making. Courses included are those designed for university students preparing themselves for a career, as well as for practicing businessmen and managers.

Methodology

One part of the research process involved a review of pertinent literature in the field of Computer

Assisted Instruction. This included books, recent periodical articles and selected reports and papers available through the Educational Resources Information Center (ERIC) in Washington. Most of the other materials were found in the George Washington Library or in the personal collection of A. M. Wildberger, for whose assistance I am grateful. Wildberger is a Navy Commander, currently Head of System Development at a local naval EDP activity, and has done considerable research in the field of CAI. Another part of study included a brief questionnaire submitted by mail to fifty large university business schools to determine the extent to which CAI is currently being used. Conclusions have been based upon both the literature and opinions expressed in the interviews.

Organization

Chapter I provides background about the field of CAI and introduces pertinent terminology. The significance of the research question is addressed, as is the scope of the research that has been performed. The key point is that there is an increasing need for business and managerial education and CAI appears to have great potential as a technique to help satisfy this need.

CAI and concepts of individualized instruction are examined in Chapter II. CAI has proven quite successful in several curricula as exemplified by the PLATO IV

System. Recent advances in computer learning can be attributed mainly to developments in CAI programming languages and in remote terminal technology. Of the several types of applications for CAI programs, the most significant learning progress is made by students who have a greater amount of control over the computer.

Chapter III provides a discussion of the psychological aspects of CAI. Emphasis is given to the importance of considering human factors when designing systems for computer-aided learning. The limitations of CAI programs are examined and it appears that educational philosophy rather than technical capability is the significant limitation.

Recent advances in computer terminals and telecommunications are described in Chapter IV. A significant development in recent years is the rivaling philosophies of centralized versus decentralized processing. These two environments have been made possible by the advent of minicomputers and the increased storage and processing capabilities of powerful large-scale computers. Both appear to have a key role in educational computing.

In Chapter V an examination has been made of applications specifically related to the business and management field. Simulation and gaming techniques are discussed. Several business schools currently use some

CAI courses but more traditional methods still prevail.

Chapter VI summarizes the research findings and presents conclusions.

Statement of Hypotheses

As the analysis proceeds in attempting to answer the research question, it is anticipated that several conclusions will emerge. Research into natural language theory will enhance the development of more flexible and useable CAI languages, which will help reduce psychological barriers to CAI usage by business students and practicioners. In addition, increased exposure to CAI should overcome reluctance on the part of curriculum planners and teachers. As a result more conceptual and heuristic courses will be developed in the business and management field.

It is expected that advances in remote terminal technology will continue and that rather sophisticated cathode ray tubes (CRT's) and multi-media devices will be available at a reasonable price. This terminal availability, combined with reduced cost per operation of central processing units will allow more business students and practicioners to use CAI applications once they are developed. Minicomputers will be readily available at the local level so that business institutions or government agencies can provide processing support for CAI courses developed centrally or commercially. Advances in telecommunication networks should encourage commercial development of CAI courses which would be available to businesses and agencies through terminal tie-in at only a time-sharing cost.

The research for the thesis has been performed with these hypotheses in mind in order to evaluate their validity.

CHAPTER II

COMPUTER ASSISTED INSTRUCTION APPLICATIONS

The purpose of this chapter is to give an overview of the developing use of Computer Assisted Instruction (CAI), of the different levels of CAI instruction modes, and of the cost factors involved in the development of a CAI system. This discussion of computer-aided learning and the theory of individual instruction introduces a variety of specialized terms which are used later in the study. (See comprehensive glossary contained in Appendix A.)

Factors Concerning Computer-Aided Learning

"A recurring theme in American educational thought has been the individualism of instruction."[1] Particularly in recent years the developers of school curricula have attempted to enable each student to progress at his own unique pace. The trend toward

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[1] F. Baker, "Computer-Based Instructional Management Systems: A First Look," Review of Educational Research 41, no. 1 (1971) :51.

individualized curricula raises this fundamental question: "To what extent does society want to commit itself to accentuating differences in cognitive style by individualizing techniques of teaching that cater to these differences?"[1] The advent of computers and their adaptation to instructional uses makes this question very timely. Based upon a review of recent literature, it appears many American educators believe that individualized instruction is essential and that CAI can become a key tool in the instructional process.

There are several reasons why CAI is received with so much enthusiasm: CAI is a very absorbing process and it results in total student involvement; a person can progress at his own pace in accordance with his desire and ability; feedback to response is stressed, for both the teaching and learning process; and finally, it is easy to write and edit lessons from student terminals.[2] In addition to generating such response, CAI has contributed two things to educational development. First, CAI has forced teachers and course designers to specify the conditions of learning very precisely. Second, CAI

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[1]Patrick Suppes, "The Uses of the Computer in Education," Scientific American 215, no. 3 (1966):220.

[2]D. Alpert and Donald L. Bitzer, "Advances in Computer-Based Education," Science 167 (March 1970):1585.

causes the identification of many problems suitable for research. Because of this latter contribution it is possible that CAI may lead us to the solution of problems which have persisted for years.[1]

In spite of the claims by the proponents of CAI, there is at present only limited success and future developments are uncertain. Yet the usage of computers for instructional purposes is increasing each year and it appears that CAI will in the future become a more important factor in American education. Expenditures for instructional computer usage have increased more rapidly than those for administrative and research purposes. By 1967, thirty per cent of the $228 million expended for university computers went toward instructional computer usage. (Figure 1) Only two years earlier the corresponding expenditures amounted to only twenty per cent of total usage.[2] In 1969, there were fifty-one centers producing their own CAI software; by 1973 the number had risen to 176 centers.[3] Also by 1973 over

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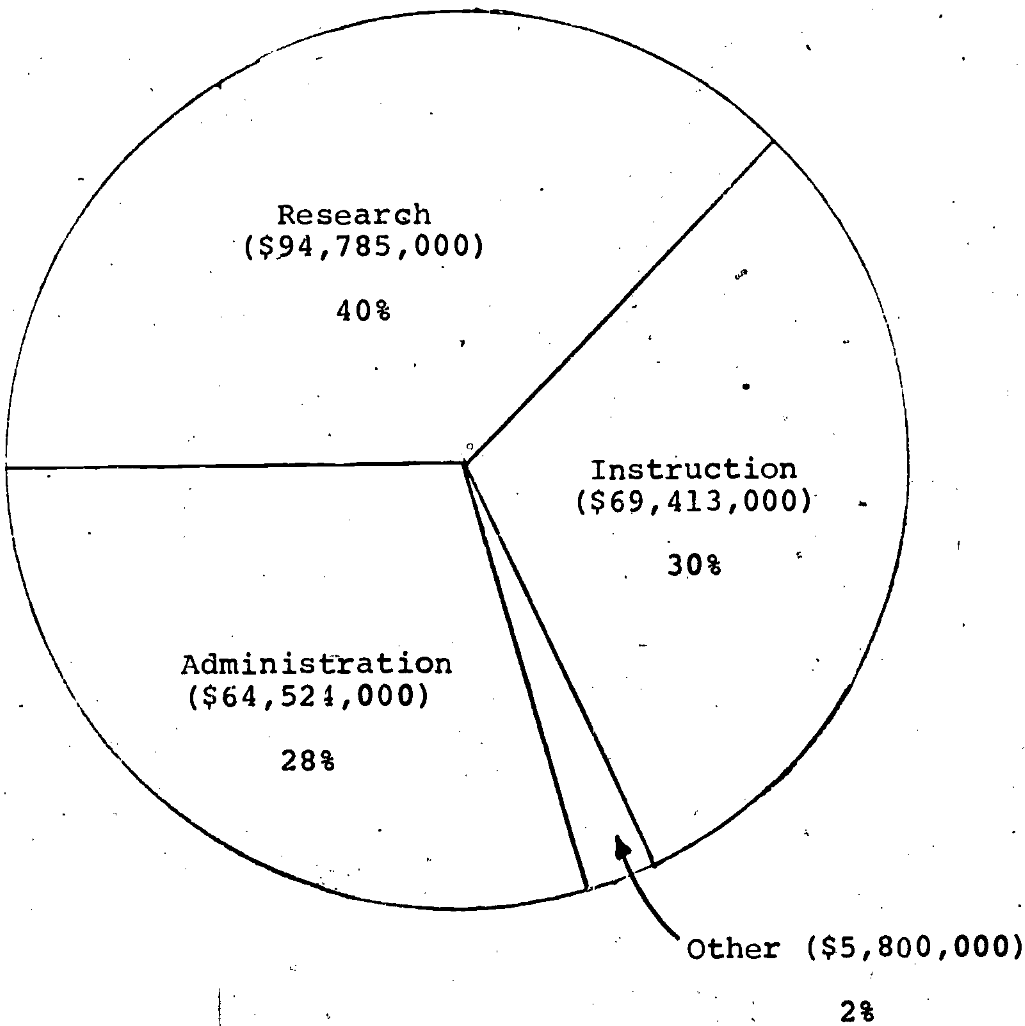
[1]L. Stolurow, "Some Factors in the Design of Systems for Computer Assisted Instruction," in Computer Assisted Instruction, eds. Atkinson and Wilson (New York: Academic Press, 1969), p. 91.

[2]Levien, The Emerging Technology, p. 152.

[3]Guy Chevalier and Bernard Gateau, Report on the Instructional Use of the Computer, 3 vols. (Bethesda, Md.: ERIC Document Reproduction Service, ED 092 086, 1974), 3:1.

FIGURE 1

COMPUTER USES IN HIGHER EDUCATION



SOURCE: Roger E. Levien, The Emerging Technology (New York: McGraw-Hill, 1972), p. 152.

eighteen hundred CAI programs were available from developing institutions.[4]

The emergence of computer-aided instructional techniques has introduced a series of specialized terms. Computer Assisted Instruction (CAI) is a process that includes any activities related to using computers in an instructional manner. Computer Managed Instruction (CMI) is a process which pertains more to administrative functions and includes such factors as test preparation, student response patterning, achievement level monitoring and curriculum planning. CAI is often used in conjunction with CMI. The term Programmed Instruction (PI) refers to any type of automated learning method. CAI is one subset of PI. All of these terms are to be contrasted with Traditional Classroom Instruction (TI), in which computers do not play a role. CAI programs can be described as linear or branching. Linear programs are those in which the path of the program logic is fixed, regardless of the response. In a branching program, the logic allows for alternative or looping paths depending upon a person's response. Most CAI programs use at least some form of branching technique.

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[1]Ibid., p. 41.

Computer Assisted Instruction Use in Conjunction with Classroom Instruction

The American educational system has been in a state of development for nearly two hundred years. Particularly during the twentieth century the public school system has expanded greatly and American universities have increased their enrollment tremendously. Yet it has been only during the last fifteen years that computer-assisted instructional technology has been used in the American classroom, and even today only a small percentage of classrooms have access to CAI courses. Because of this fact, most teachers are relatively unfamiliar with computer technology used in the classroom and may have some misconceptions and even apprehensions about CAI. Such misconceptions arise from distorted attitudes about a computer itself. It is not correct to imply that a computer is like a model of a teacher's brain and that CAI can therefore replace the teacher. The computer is an instructional resource that can model one or more aspects of an educational process.[1] Another unusual analogy has been drawn between the computer and a university: "A university is primarily a system for storing, retrieving, processing, disseminating and

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[1]Ibid., p. 67.

creating information..; and computers do exactly the same thing, even creating information..."[1] This creation of information comes through research in higher institutions of learning, and such research potential is present in computer-based mathematical algorithms which simulate real events.[2]

One major difference between the Traditional Instruction (TI) environment and the CAI classroom is in the area of curriculum development. Traditionally, the professional teacher would prepare a unit of instruction from an outline and, if he is skillful, would adapt his teaching strategy during class time. In contrast, a team of both professionals and non-professionals participate in CAI design. The design team can build into the course the flexibility desired for individualized progression. Such adaptiveness can be built into the program in advance.[3]

One hypothesis about the culmination of computer usage in education has been proposed as follows:

> The most important impact on education of computer technology...will probably be by supplying a tool for finding out what we are doing, for turning anecdotal impressionistic answers into scientifically testable ones, and so turning what has been almost purely an art

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[1]Ralph W. Gerard, ed., Computers and Education (New York: McGraw-Hill, 1967), p. 15.

[2]Ibid.

[3]Hicks and Hunka, The Teacher and the Computer, p. 33.

> into a respectable science - and without eliminating the artistic aspects either. Research in education, advances in educational understanding, education as a behavioral science will, I think, be the most important outcome.[1]

The significant point of this hypothesis is that it suggests that computer-aided learning is more than just a technique to improve teaching methods; it has the potential of reshaping the fundamental definition of education.

Characteristics of CAI Applications

CAI programs have been designed to fulfill a variety of requirements. They are also written at different levels of complexity. One way to describe CAI programs is to define them as linear or branching, depending on their logic capability. There are several other ways to categorize CAI applications. One frequently used taxonomy distinguishes three types of CAI systems: drill and practice, tutorial and dialogue. A drill and practice system supplements the regular curriculum. It offers the student an orderly way to master various fact or algorithms which educators feel must be practiced to be learned well. Word recognition, spelling and basic mathematic functions are examples of material appropriate for drill and practice programs. In a tutorial system the computer assumes the main role in the teaching process.

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[1] Gerard, Computers and Education, p. 14.

Frequently extensive branching techniques are used so that a student can complete the course work at his own pace. Technical training courses have used tutorial CAI systems with success. A dialogue system is more advanced than either drill or tutorial in that the response pattern of the program is controlled by the student. In such a system it appears that the student and computer are engaged in a question and answer session. (Figure 2) One major problem in designing a dialogue or Socratic system is for the computer to recognize precisely what questions or responses have been entered.[1]

Another way to classify CAI systems is by the type of requirement or need they satisfy. First, there are systems designed for problem solving in which the student attempts to solve a specific set of computational problems using a procedural language like FORTRAN. This implies either that FORTRAN routines must be defined in advance and stored, or that they are to be developed by the student as specific problems arise. A second need is for the familiarization with and mastery of various facts or patterns. Drill and practice systems are designed to help a student achieve such mastery. A third type of CAI system can be called inquiry or data retrieval as

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[1]Suppes, "The Uses of the Computer in Education," pp. 215-19.

FIGURE 2: CAI DIALOGUE SYSTEM

PHYSICAL EXAM? (STUDENT)

Fine. What in particular would you like to know? (COMPUTER)

CHEST EXAM?

It is common practice in the medical profession to begin an examination by checking the patient's general appearance.

GENERAL APPEARANCE?

Acutely prostrated, lying in bed on his right side. Looks acutely ill, sweaty, apprehensive, but alert. Paroxysmal cough, bringing up a little rusty streaked sputum. Breathing with difficulty.

EENT EXAM?

Check all of the vital signs first!

TEMPERATURE?

103.

BLOOD PRESSURE?

150 84.

PULSE?

100 a minute. Occasional extra systole.

RESPIRATORY RATE?

20 a minute and shallow.

[*Several requests and responses have been deleted from the dialogue at this point for the sake of brevity, including interchanges about abdominal, chest, and eye-ear-nose-throat examinations.*]

COUGH?

Yes, developed yesterday.

BACKACHE?

No.

HEART EXAM?

Not enlarged to percussion but low-grade systolic murmur at apex. Otherwise normal.

ABDOMINAL EXAM?

Diffusely tender, some splinting noticed in lower right quadrant and occasionally radiating to right flank area.

THE GRIPPE.

There's insufficient information for any conclusive diagnosis at this time. You're not being careful!

MUSCULO-SKELETAL SYSTEM?

Essentially negative, except for generalized weakness and aching.

EXTREMITIES?

Normal, except nail beds are questionably cyanotic but difficult to determine because of patient's skin color.

RECTAL EXAM?

You're not being careful! The patient is too acutely ill for a rectal examination.

LABORATORY REPORTS?

Fine. Which lab tests would you like to have done?

RBC?

A red count will be done. Results will be sent to you as soon as possible.

WBC?

The WBC will be taken.

[*Deleted: requests for laboratory tests such as urine, x-rays, and blood culture, and the results of these tests promised by the computer.*]

NOSE AND THROAT SMEAR AND CULTURE?

They'll be ordered now. When you've requested all the lab reports you want, let me know that you're ready to proceed.

PROCEED.

You may want repeats on some of the lab work. Would you like to alert the night nurse to set up the lab tests you'll want to see tomorrow?

YES.

Good. That will speed things up. However, there's nothing further that can be done tonight to help the patient. Let's call it quits for now. Perhaps you'll be in a better position to diagnose the case tomorrow after the first lab reports come in and you have reexamined the patient. Have a good night's sleep and when you're back on duty tell me to "proceed."

PROCEED

It's morning and you're making your rounds. You've come to our patient and are given the night nurse's report: "Temperature remained high but patient spent a reasonably comfortable night. Cough diminished but persists. Occasional traces of blood in sputum. Patient still dyspneic and still has pain in abdomen. The second series of lab tests was initiated."

Some of the first series of lab reports have just come in: urine exam, insufficient fluid for analysis: RBC, 5 million; WBC, 15500; differential, shift to left. When the other reports are in you'll be notified. Before proceeding with the reexamination it might be instructive to pause and consider the diagnostic implications of the information at hand. Perhaps you think it too early to arrive at any definitive conclusion. On the other hand, you may be prepared to make the diagnosis now. Are you?

NO.

Fine. Nevertheless, we've got a fair amount of information — at least enough to raise some, perhaps several, diagnostic possibilities. Have you any in mind?

YES.

Name one.

PULMONARY INFARCTION.

Fine. Pleural pain, dyspnea, fever and the physical exam signs and symptoms are certainly consistent with pulmonary infarction. Do you think that shaking chills and the presence of rusty sputum further support this diagnosis?

NO.

Right. Though the white count is consistent, isn't it?

NO.

Wrong. The white count is consistent. This should further support your diagnosis. We've considered one possibility. Do you have another diagnosis in mind?

NO.

In that case I'd like to talk about viral pneumonia. The tachycardia, high WBC, elevated respiratory rate, shaking chills, bloody sputum, and severe pleural pain all lend weight to that diagnosis—right?

YES.

You're way off base. There's not an iota of truth to any part of what I just said; in fact, the opposite of what I said is true. You'd better review some elementary medicine, doctor.

[*Deleted: the results of some laboratory reports requested the previous day.*]

SOURCE: John A. Swets and W. Feurzeig, "Computer-Aided Instruction," Science 150 (October 1965):574.

exemplified by library collections available from a terminal or the New York Times Index system. This type of CAI usage provides the student with research capability to supplement other textbook or lecture materials. Finally, the computer may be used for simulation and gaming techniques in which some real-world phenomenon or process is represented symbolically in the computer, usually by a series of mathematical algorithms. The intent in this type of CAI system is to provide an opportunity for the student to test out theories of problem solving in a simulated environment.[1]

In yet another taxonomy of the types of CAI systems, a close correlation has been measured between the increasing student control of the program and the capability of the computer that is being used. (Figure 3) The significance of this correlation is twofold: first, that CAI systems will be enriched if they are designed to use the computer's power as a word and event processor, rather than merely as a calculator and brancher; and second, that the CAI technique itself becomes much more powerful as the student participates in specifying the content and direction of the programs.[2] This emphasis on student involvement in the design and presentation of CAI systems

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[1]Stolurow, "Some Factors in the Design of Systems for Computer Assisted Instruction," p. 81.

[2]Milner and Wildberger, "How Should Computers be Used in Learning?," p. 8.

FIGURE 3

CONTINUUM OF INSTRUCTIONAL USES OF COMPUTERS

"Information Structure Oriented" or Student Controlled Learning

- STUDENT DESIGNED AUTOMATION
- STUDENT DEVELOPED SIMULATIONS OF REAL SYSTEMS OR PROCESSES
- OPEN-ENDED PROBLEM SOLVING (Student Solution of Student-Posed Problems)
- STUDENT OPERATED AUTOMATA
- STUDENT DEVELOPED TUTORIALS
- EXPLORATION OF SIMULATED SYSTEMS OR ENVIRONMENTS (Computer Simulated Experiments)
- INTERACTIVE INFORMATION RETRIEVAL

"Frame Oriented" or Computer Monitored Instruction

- COMPUTERIZED INDIVIDUALLY PRESCRIBED INSTRUCTION
- CALCULATION (Electronic Sliderule)
- TUTORIAL Computerized Programmed Instruction)
- TESTING AND RECORD FILING
- DRILL AND PRACTICE

↑ Increasing Student Control

SOURCE: Stuart Milner and A. M. Wildberger, "How Should Computers Be Used in Learning?," Journal of Computer-Based Instruction (August 1974):10.

has brought forth the classification called dual and solo modes. These modes are analogous to the situation of an airplane pilot who needs an instructor present at first (dual), but who later makes his first flight by himself (solo). There are four levels of CAI progression, two in each mode. They are:

a. Category I - The student receives information from the computer, responds appropriately, and then branches to the program logic corresponding to his responses (Dual).

b. Category II - There are only general constraints on the subject matter by the computer. Within the overall framework, the student controls the specific application. This mode has been called learner - directed CAI (Dual).

c. Category III - The student develops his own program to assist him in the learning process. This is learning-devised processing (Solo).

d. Category IV - This is a serendipitous mode wherein the student's program creates knowledge in the sense that it illuminates others. This mode has been labelled learner-organized learning (Solo).[1]

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[1]Thomas A. Dwyer, "Some principles for the Human Use of Computers in Education," <u>International Journal of Man-Machine Studies</u> no. 3, (1971):225-26.

Recent Advances in CAI Technology

The extension of CAI to new subject matter and wider educational use has produced a series of advances in the last few years. One of the most important developments has come in programming languages for CAI usage. Programming languages tailored for use in instructional systems are available in ever-increasing numbers. During the late 1960's scholars and system designers developed several languages which were adapted from existing compiler languages. For example, FORTRAN was used as a starting point for developing a language simpler to use without a great deal of experience. The resulting product was called QUICKTRAN and this language is suitable for both CAI and conventional EDP systems. Approximately twenty such adapted languages have been developed. (Table 1) More recently another group of programming languages have been specifically designed to be CAI author languages. At least a dozen such languages belong to this category.[1] These CAI author program languages provide several features not afforded by the earlier adapted compiler languages. First, they are much more sensitive to potential users who may not be knowledgeable in EDP programming techniques.

[1]Charles H. Frye, "CAI Languages: Their Capabilities and Applications," Datamation, September 1970, pp. 318-19.

TABLE 1

EXAMPLES OF CAI LANGUAGES

Language	Developer	Language	Developer
ADEPT	International Business Mach.	FOIL	University of Michigan
APL	Science Research Assoc.	INFORM	Philco-Ford
BASIC	Dartmouth College	JOSS	RAND Corp.
CAL(UCI)	Univ. California/Ervine	LYRIC	Computer Assisted Sys, Inc.
CAL(SDS)	Scientific Data Systems	MAD	University of Michigan
CATO	University of Illinois	MENTOR	Bolt Beranek and Newman
COMPUTEST	University of Cal./San Fran.	OPL	M.I.T.
COURSEWRITER	International Business Mach.	PLANIT	Systems Development Corp.
DIALOG	Technomics, Inc.	QUICKTRAN	International Business Mach.
ELIZA	M.I.T.	TELCOMP	Bolt Beranek and Newman
CAN	Ontario Inst. in Education	TINT	Systems Development Corp.

SOURCE: Charles H. Frye, "CAI Languages: Their Capabilities and Applications," Datamation, September 1970, pp. 323-24.

Both the author and student can learn them more quickly and more feedback is provided during course development. These CAI author languages offer much better lesson handling capability, in that they automatically structure output data and specify clearly the conditions for input. Most of these languages provide several record handling features including the compilation of historical and statistical data and presentation of pertinent information to both the student and teacher based upon the stored data. Conditional branching techniques are much more sophisticated because not only do they adapt to the alteration of instruction sequence by the use of various counters, but they also are sensitive to the student's previous set of responses. Finally, the newer CAI author languages have complex answer matching service routines. This factor is significant in that such routines provide for response recognition by the computer. Techniques used for response matching include key word, partial, phonetic and character string.[1]

Another major factor in recent CAI development is in remote terminal technology. Advances in this field have enabled CAI systems to take advantage of the larger and faster central processing capability. One recently-developed system which has used a variety of remote

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[1]Ibid., pp. 320-22.

terminal media is TICCIT (Time-shared Interactive, Computer Controlled Information Television). This system, a combined effort of MITRE Corporation, the University of Texas and Brigham Young University, uses a Sony Color T. V. Display. This terminal can present digitally generated characters and graphic displays in a multitude of colors. Also, pre-recorded audio and video tapes can be switched to the terminals.[1] Another system to explore the use of new techniques with remote terminals is PLATO IV (Programmed Logic for Automatic Teaching Operations). Developed by Donald L. Bitzer at the University of Illinois, PLATO IV is the most widely known CAI system. PLATO IV has achieved this distinction for several reasons. Now in its fourth level of development, the PLATO system will ultimately provide CAI access to four thousand terminal users simultaneously. The system is centralized in that all computing power and services are provided by one central facility. The hardware and software combination is so well integrated that response time to any remote request averages less than one second. The PLATO IV

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[1]C. Victor Bunderson, "Team Production of Learner-Controlled Courseware: A Progress Report," Proceedings of the International School on Computers in Education, (Provo, Utah: n.p., 1973), p. 3.

network of services provides courses for many academic levels (pre-school to graduate university) in a wide array of subjects, including business courses. One unique feature developed specifically for PLATO IV is the plasma display panel. This panel, which serves as the primary terminal screen for the student, contains ionized gas imbedded between two glass sheets. Extensive color graphic depiction is possible on the plasma display panels. In addition, PLATO possesses two independent capabilities called the electronic book and the electronic blackboard. The book contains hundreds of slides or pages instantly available on the plasma panel. The student can depict certain characters and plot straight line segments on the blackboard, for computer analysis or retention.[1]

Application by Subject Matter and Educational Level

The earliest CAI courses were developed for those subject areas susceptible to the primary drill and practice routines. These include arithmetic and algebraic mathematics, spelling and word recognition, and technical training fields.[2] But CAI course development has spread rapidly into many other subject areas. In the field of

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[1]Allen L. Hammond, "Computer-Assisted Instruction: Two Major Demonstrations," Science 176 (June 1972):1112.

[2]Hicks, The Teacher and the Computer, pp. 36-37.

mathematics, coursework prepared for computer assistance includes geometric graphic displays, complex matrix algebra and set theory of the "modern math."[1] Applications in the sciences have proven extremely useful. In chemistry, programs are used for simple equation balancing as well as for the complexities of qualitative analysis. Simulation of phenomena in the world of physics allows students to test out theories on a screen which would otherwise be static pictures and words in a text book. Medical diagnosis has lent itself well to interesting dailogue-type CAI applications. Both video and audio techniques have accompanied such programs to recreate more vividly medical symptoms that are under the student's analysis.[2] The Los Angeles County General Hospital has had very successful results using a computer-controlled mannequin called "Sim One" to teach anesthesiology.[3]

The applications developed for CAI course work have spread into less well-structured fields as well. Subjects include education, law, social sciences, architecture, psychology and business administration. There were over seventeen separate fields in which CAI

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[1]Ibid.

[2]Ibid.

[3]Chevalier and Gateau, Report on the Instructional Use of the Computer, 1:50.

courses have been used. Some 13,400 programs were available in American universities as of 1967. As of that time three academic fields stand out as the major CAI users. These are engineering, computer science, and business and commerce. Together they comprise over three-fourths of student participation and expenditures.[1]

CAI courses have been used at all levels of education, from early primary grades to university graduate programs. When computer-aided learning has been introduced into primary and even secondary schools, it is usually a result of a university or federally funded research project. For example, the Massachusetts Institute of Technology (MIT) has developed a computer-driven mechanical device called a turtle. (Figure 4) The turtle can perform three basic functions: advance a specified number of units, rotate a set number of degrees, and leave a penmarked trace of its path. The researchers at MIT have used the turtle to let grade school children experiment with concepts about geometry and numbers in general. These scientists are attempting "...to put children in a better position to do mathematics rather

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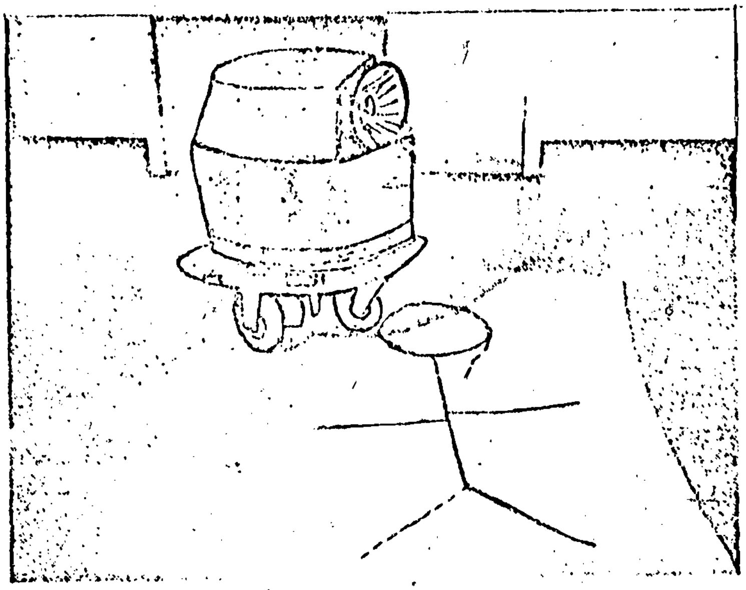
[1] Levien, The Emerging Technology, pp. 178-79.

FIGURE 4: PAPERT'S "TURTLE"



The picture shows one of our turtles . . . so-called in honor of a famous species of cybernetic animal made by Grey Walter, an English neurophysiologist. Grey Walter's turtles had life-like behavior patterns built into its wiring diagram. Ours have no behavior except the ability to obey a few simple commands from a computer to which they are attached by a wire that plugs into a control-box that connects to a telephone line that speaks to the computer, which thinks it is talking to a teletype so that no special system programming is necessary to make the computer talk to the turtle. (If you'd like to make a fancier turtle you might use a radio link. But we'd like turtles to be cheap enough for every kid to play with one.)

The turtle can send signals back to the computer. These signals appear to the computer just like the signals from a teletype -- so, again, no special system programming is necessary to make a turtle talk to a computer. Where do the signals come from? They are generated by sense organs attached to the turtle. Our turtles do not have a fixed set of sense organs. Rather, they have inlets into which one can plug wires to attach any sense organs one is clever enough to make. Touch sensors, light sensitive cells and sound detectors are obvious examples that require very little cleverness. Accelerometers and tilt detectors lead to more sophisticated fun.

Turtles can have effector organs as well. The activities described here use only a simple one -- a pen located at the turtle's center, which can be lowered to leave a trace of the turtle's path, thus turning it into a remarkable geometric instrument.

SOURCE: Seymour Papert, "Teaching Children Thinking," Programmed Learning and Educational Technology 9 (September 1972):248 passim than merely to learn about it."[1] In another example, the Montgomery County Public Schools embarked upon a research project in 1968 to introduce CAI courses into all levels of the county curricula on a limited basis.[2] And finally, the University of Pittsburgh developed several courses for the local public school system.[3] Some of the research findings will be discussed in Chapter III.

A much greater proportion of CAI systems were available on the university campus, mostly because of the increase in the number of computers and the emphasis upon educational research in recent years. As of 1967 nearly 400,000 American university and graduate students were enrolled in CAI courses.[4]

An Assessment of CAI Costs

In order for a CAI system to be successful, it must be carefully designed to fulfill specific requirements. Also the presentation methods must be well-conceived so

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[1]Seymour Papert, "Teaching Children To Be Mathematicians vs. Teaching about Mathematics," International Journal of Mathematical Education on Science and Technology 3(1972):249.

[2]Alex Dunn and Jean Wastler, Computer-Assisted Instruction Project: Final Report, Project Reflect, Title III, ESEA of 1965 (1969-71).

[3]Dwyer, "Some Principles for the Human Uses of Computers in Education," pp. 219-39 passim.

[4]Levien, The Emerging Technology, p. 178.

that the design considerations can be implemented properly. Another aspect of CAI that has a significant effect upon its development and usage is the associated cost. If costs are too high, sponsorship of CAI development will not be enthusiastic and widespread usage will be difficult to achieve.

There are four major costs factors to be considered in the design of a CAI system: system development itself, including feasibility and planning time; lesson preparation; lesson presentation techniques; and terminal operation and maintenance.[1] As the development of CAI systems approaches the point where they are available to a number of users through a time-sharing service, the cost factors can be viewed from a different viewpoint. The viewpoint is that of a potential user who will have to consider how costly CAI systems or programs will be to use. One cost factor to be considered is the computational requirement which includes the amount of primary and secondary storage needed as well as the cost per operation of the central processor. Although storage requirements and computations in CAI programs have tended to increase in recent years, projected declines in cost by a factor of one hundred for these features will more than offset the increased requirements. Another cost factor is the telecommunication

[1]R. Simonsen and K. Renshaw, "CAI...Boon or Boondoggle?," Datamation, March 1974, p. 90.

and transmission facilities that will be needed. Geographic location is an important aspect of this factor. Costs will be minimized if the host computing center is located on the university campus, or within the commercial or government facility. The most costly factor of a CAI system is still that of developing the instructional software. The concept anticipated in the future is to develop CAI systems and store them on a library for widespread use. Although course preparation costs will rise slightly, expected usage expansion will reduce the cost per student hour. This development cost will become proportionately higher as hardware-related costs continue to decrease. A final cost factor to be considered is that of supporting services. These include costs associated with installation facility management and related supervision. Such costs could increase as more specialized materials are required in CAI applications.[1] In summary, it is likely that the costs to use CAI will decrease during the coming years. Early courses cost as much as fifteen dollars per student contact hour, PLATO IV has been estimated at two dollars per hour, and "...it appears that costs of fifty cents per student hour will be available to institutions of higher education..."[2]

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[1]Levien, The Emerging Technology, pp. 485-87.

[2]Ibid., p. 487.

Summary

CAI is relatively new as a technique in American education. Its introduction has raised significant questions about the concept of individualized instruction since CAI is potentially useful for this purpose. Most users have been very enthsiastic about CAI and, in spite of limited use to date, its application is increasing. CAI can be a powerful instructional resource in the educational process and some proponents believe it can significantly affect traditional instruction methods.

CAI can be developed at several levels of complexity including drill and practice, tutorial and dialogue. CAI systems also are designed to satisfy such requirements as problem solution, fact retention or mastery, data retrieval and research using simulation techniques. It appears that CAI has a more significant effect upon students who have a greater amount of control over the computer and program routines to be developed.

Recent advances in CAI center around programming languages and remote terminal technology. Newly developed author languages specifically tailored for CAI usage are user oriented, provide extensive lesson handling capability, compile statistics, offer sophisticated branching and have complex answer matching routines. A variety of advanced remote terminal features are available in many systems, including TICCIT and PLATO IV.

Most existing CAI applications are used for drill and practice routines, engineering, mathematics and science but some research has been performed in less well-structured subjects such as education, law, social sciences and business theory. CAI programs are available at all levels of education, from primary grades to the university graduate level.

Cost factors to be considered in CAI systems include computation, communication, courseware development and supporting services. As CAI programs are stored in libraries that are available for widespread usage, the cost per student hour is likely to decrease considerably.

CHAPTER III

PSYCHOLOGICAL ASPECTS OF THE CHARACTERISTICS OF COMPUTER ASSISTED INSTRUCTION

Authorities generally agree that many people have a distorted idea of what functions a computer can perform. The average person's exposure to a computer includes such experiences as credit and billing systems, annual voting tabulations, and automated tax returns. When such operations run smoothly, people pay very little attention to them. When a malfunction occurs, however, people tend to ascribe nearly human attributes to computers, seemingly unaware that the computer only responds unemotionally to logical instruction sets prepared by human beings. It is most common for people without some exposure to a computer environment to misinterpret the statement "The computer broke down." They fail to realize that this usually means a systems analyst or programmer has improperly defined a procedure or miscoded an instruction or that incorrect data has been introduced into the system. Such misconceptions are prevalent enough that they may affect the attitude of persons encountering a computer terminal for the first time. University business students and practicing managers and businessmen should be able to have Computer Assisted Instruction (CAI) programs that have been designed with concern for human psychological factors. Pertinent to this subject are basic considerations of the man-machine interface, including problems associated with communication patterns. These aspects are all related to the science of cybernetics which deals with the study of communications and control in complex systems.

Human Factors of Man-Machine Interface

Today, there are two major approaches to educational innovation. The first may be considered a humanistic approach in which the teacher strives to make the subject matter relevant to the student. The content of the material to be presented motivates the student to learn if this technique is successfully employed. The second approach involves the use of computer technology where proponents strive to motivate students by using the capability of the computer to enhance more traditional methods of instruction. At first these two themes seem to contradict one another. Yet if educators can properly combine the two, the common goal of an effective teaching/learning environment can be achieved. The educational process must be based upon general principles which can accommodate the humanistic goals. In turn, the principles can be imbedded in specific applications presented in various modes of instruction to those using computer technology.[1]

One factor that will play a significant role in the influence of CAI on American education is that of man-machine communications. Effective communication is an essential element in any smooth-functioning, human process. Communications problems which arise in interpersonal relations are difficult enough to solve, but such problems become even more complex in the human-computer interface.

The film "2001: A Space Odyssey" introduced to the viewing public a very unusual computer named HAL, and at the same time portrayed some strange effects of miscommunication between man and computer. HAL assists its human astronaut in a space flight, performing many complex functions. As the story develops, the communication between HAL and the astronaut breaks down and HAL begins to display human-like emotions. Eventually HAL becomes malevolent and tries to destroy its human companion. Certain real computers have performed many of the command and control functions which HAL executes in the film, but one basic difference is the way HAL receives its commands. At first the communication mode is oral, then by facial expression, and ultimately through basic human emotional perception. The bizarre saga of HAL highlighted a fact which is still true today, that human-computer communication

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[1]Dwyer, "Some Principles for the Human Use of Computers in Education," pp. 219-20.

is "...unnatural and inefficient."[1]

In spite of this fact there has been little published research to date dealing with man-machine communications. One exception is the study that Alphonse Chapanis of the Johns Hopkins University has undertaken. He has experimented with all modes of comminications among various groups of people and has concluded that the voice channel is much faster than any other means. As he began to apply his experiments to a computer, he highlighted and described the machine's intolerance of human error or variance. Although voice response has been available as output from computers for some time (for example in the Bell Telephone System which uses audio formats for new customer listings), computer recognition of human voice input has been more limited. IBM has recently developed a specialized computer that can respond to over thirty spoken commands. This example of voice recognition is primitive when compared to what will follow in the future.[2]

The element of man-machine communication is a key factor in the development of CAI applications. The following two examples demonstrate the value of effective student

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[1]"How to Talk to a Computer...and How to Listen When It Talks Back," Johns Hopkins Journal (Winter 1974):3.

[2]Ibid.

computer interaction. In one case, the student is totally absorbed as he performs a chemical synthesis experiment. He is in complete control of the command procedures and feels almost as if he is dealing with a laboratory technician who will execute his commands. Performing the same chemical experiment, another student shows a maximum consciousness of the mechanics of the process. He is continually searching through manuals to find the proper instruction commands to execute requests. His attention is not on the primary task of the chemical synthesis, but on the secondary task of surrounding mechanics and techniques. The latter example seems to be more representative of existing CAI applications. CAI designers must carefully study the communication procedures so that the primary learning task does not become subservient to the computer itself.[1]

Cybernetics and Its Relationship to CAI

Cybernetics is the science that deals with the study of complex systems and communications with an emphasis on the action - feedback - adaption cycle. Norbert Wiener's clasic work Cybernetics written in 1948 introduced this science to the public. It was a prophetic

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[1]E. N. Adams, "Technical Considerations in the Design of a CAI System," Programmed Learning and Educational Technology 9 (September 1972):263.

book in that it discussed at length the potential of complex mechanized systems at a time when the first computer was just being tested. Since that time many scientists and psychologists have performed extensive studies comparing computing systems to the human nervous system, in an attempt to better understand the brain. A cybernetic model can apply to many types of systems or processes, including both mechanical/electronic and human/social systems. A generalized cybernetic model is depicted in Figure 5. Every cybernetic system has some control point at the center of the process. This may be a person, an organization, a machine or a component part. As this control functions, it acts or moves based upon stimuli it receives from various external sources. The process iterates continuously as long as the control point exists in terms of the cybernetic system defined.

Chapter II discussed the various instructional categories of CAI systems, including the dialogue or Socratic mode. It is this dialogue mode that offers the greatest learning potential by use of the computer technology. A dialogue CAI application is an example of a cybernetic system. In this type of application both the student and the computer can be considered alternative control points.[1]

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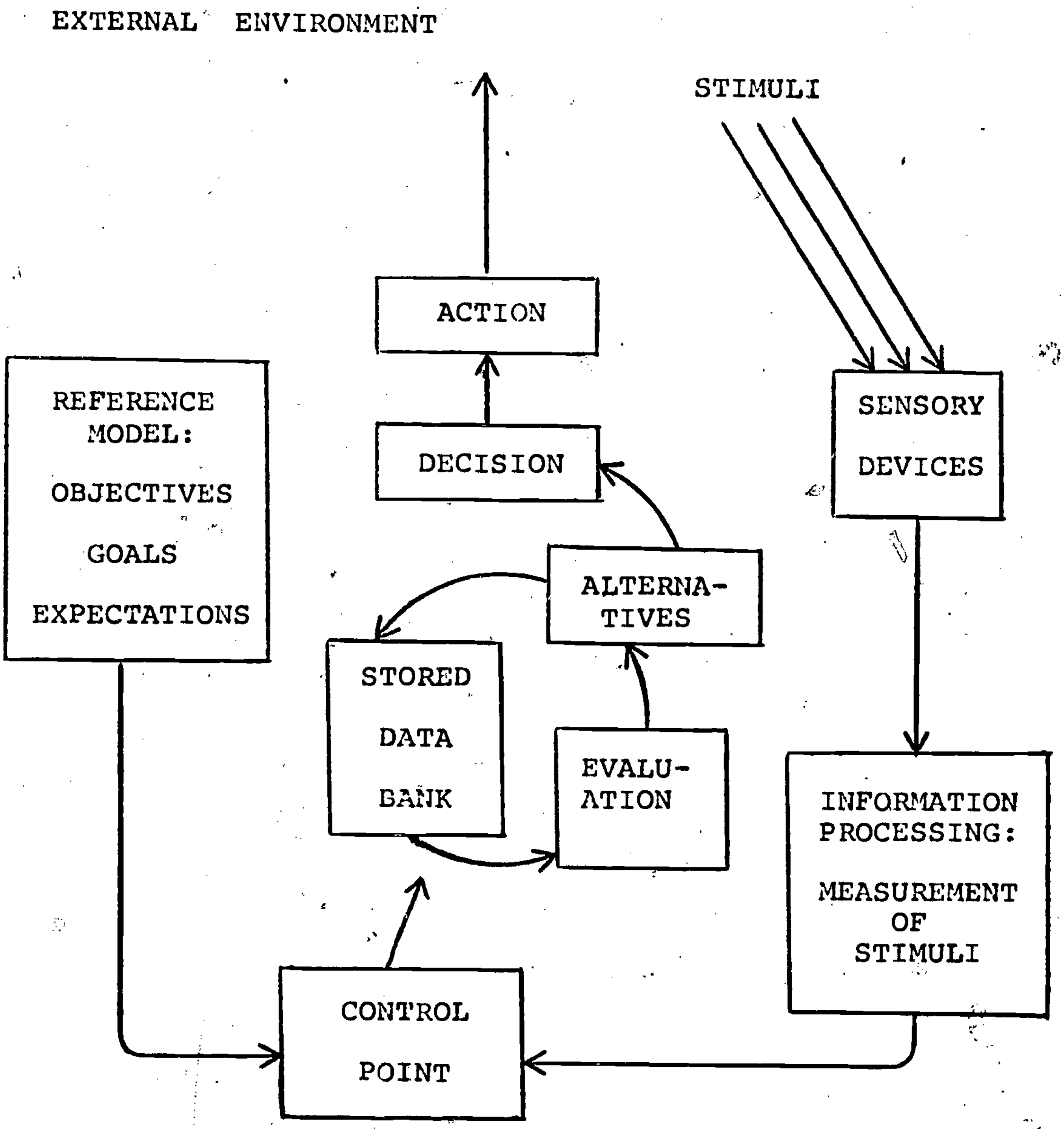
[1]The term computer here is used to include both the hardware itself and the program routines that control it.

FIGURE 5

GENERAL CYBERNETIC MODEL



The student is by intent the center of the system. It is for his or her benefit that CAI exists. The student evaluates the computer's statements and questions and responds as is appropriate. The dialogue continues in this manner with repeated feedback and response. (Figure 6) During the course of the dialogue the adaptive program evaluates outside stimuli (student responses) and alters its logic correspondingly. In a sense, then, the computer can also be described as a control point since it also functions in response to external stimuli. (Figure 7)

A CAI system which can formulate questions and responses based upon general principles rather than on prior complete specifications is called a generative system. The more highly generative a system is, the more independent it can be from specific subject matter. There are four basic elements to a generative CAI program: memory, which consists of predefined facts or data immediately available for recall; reasoning, based upon related mathematical or logical algorithms; input or student responses; and finally, output or feedback to the student in terms of statements, interpretations or questions.[1] The unique part of the generative program is the reasoning process. The algorithms enable the program to handle a great variety of data input

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[1] J. M. Perry and E. B. Koffman, "Problem Generation and Solution," Proceedings of the 1973 International Conference on Cybernetics and Society (Boston: n.p., November 1973), pp. 330-35

FIGURE 6

CYBERNETIC MODEL WITH
STUDENT AS CONTROL POINT

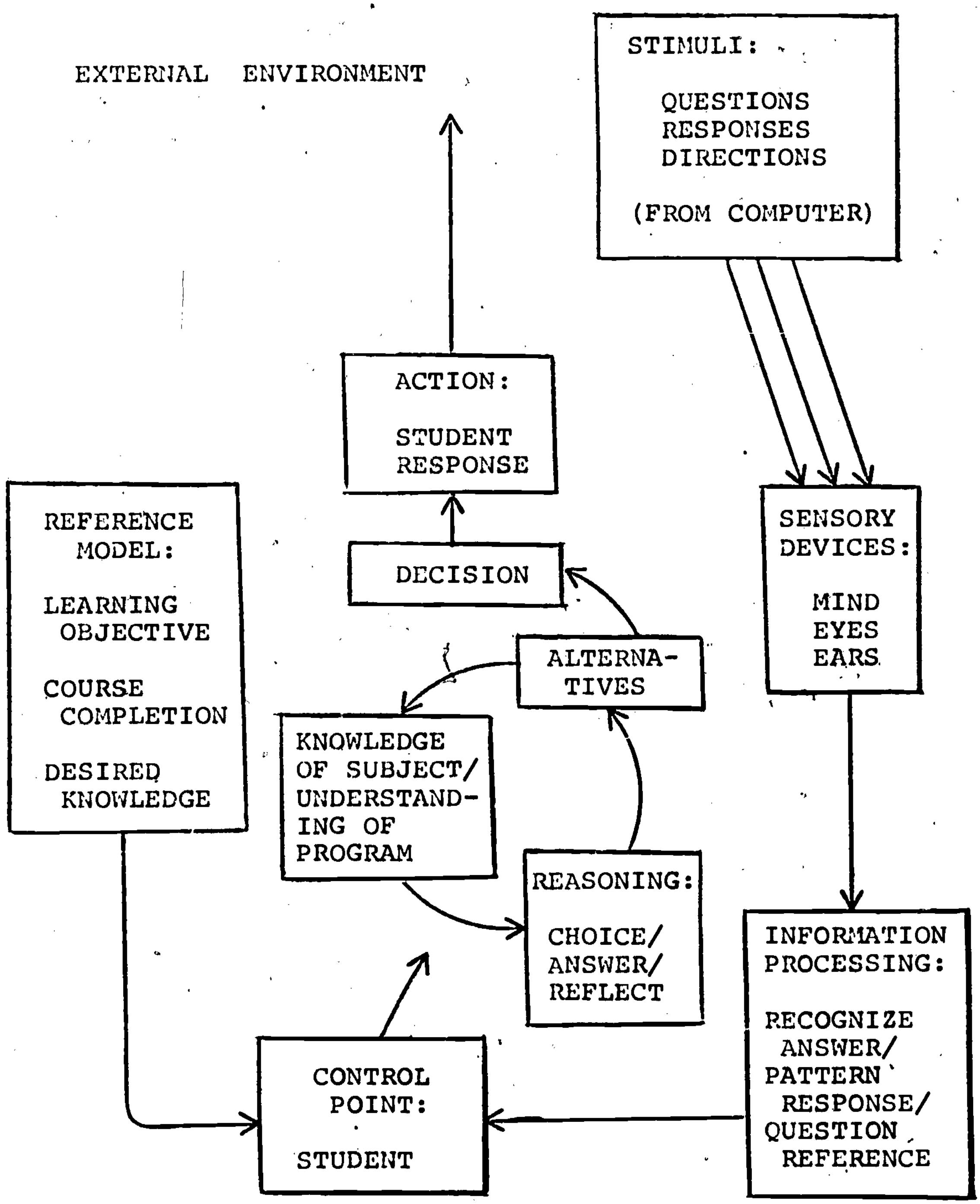
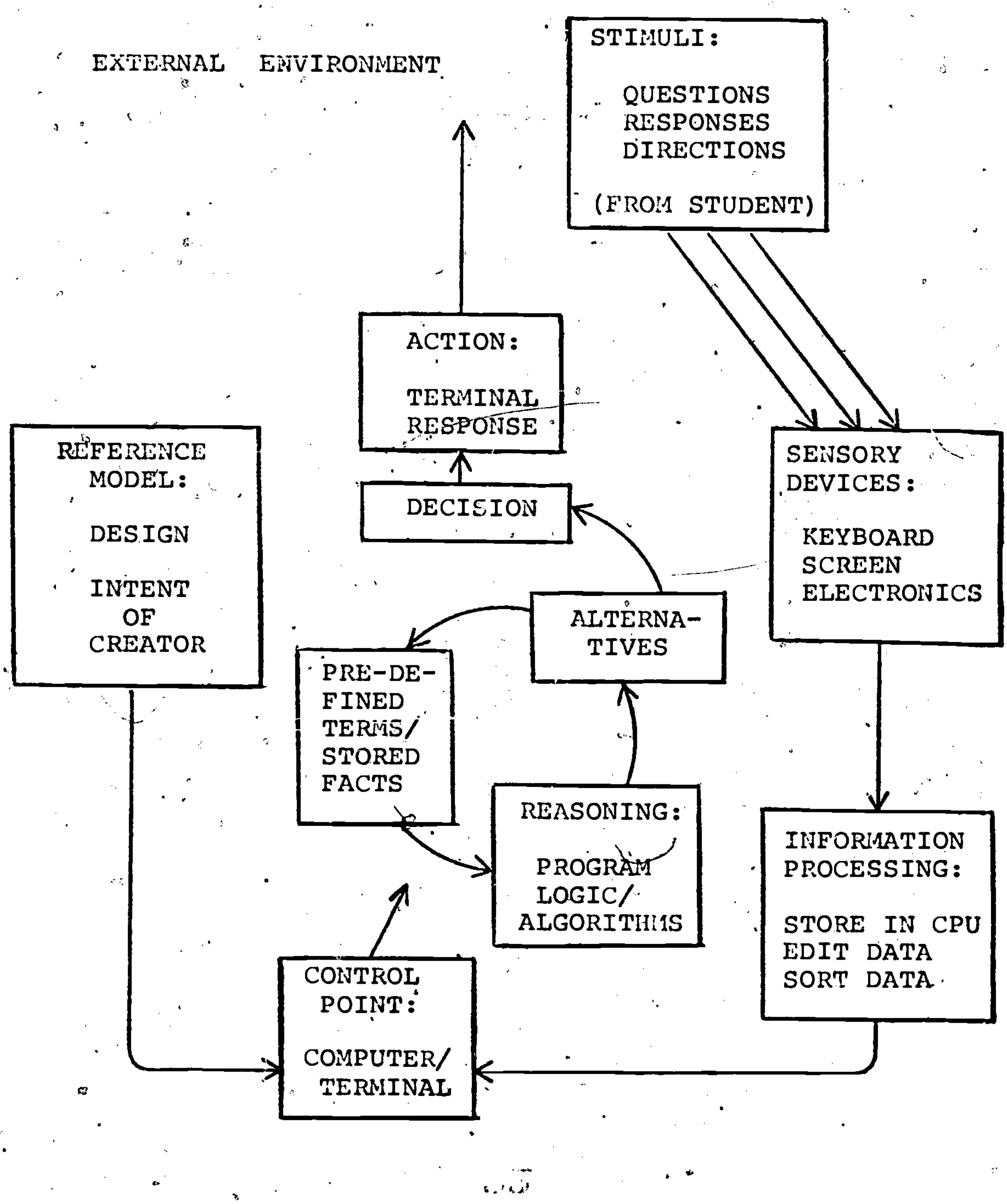


FIGURE 7

CYBERNETIC MODEL WITH
COMPUTER/TERMINAL AS CONTROL POINT



by the student and provide the capability for the computer to "learn". The computer learning process consists of continuously updating the model of the student, acquiring new information about the student through his responses, and modifying old information. In this way the computer program may proceed in directions not specifically defined in advance.

One unusual analogy has been made about the computer when it is being used during a man-machine interactive learning session. There are four phases of progression in the analogy. First, the computer acts as a benevolent mentor by acquainting the student with a problem or situation to be analyzed and solved. Next, the computer is compared to a cognizant assistant that greatly enhances the problem-solving ability of the student. Third, the computer acts as a discerning partner by enabling a genuine man-machine collaboration to solve problems. Finally, at the highest intellectual phase of progression, the computer is a learner and can be taught to approach new problems methodically.[1]

Behavioral Factors in CAI Program Design

A CAI program consists of three separate elements: content includes the body of knowledge and specific subject

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[1] H. Peele and E. Riseman, "Four Faces of HAL: A Framework for Using Artificial Intelligence Techniques in Computer Assisted Instruction," Computer and Information Science, Technical Report 73c-4, (University of Massachusetts, Amherst, Mass. [1974]), p. 348.

matter to be studied. This element also incorporates the desired behavioral objectives and the detailed system definition, including the sequence of the learning tasks. The second element, communication, includes the terminal hardware and teleprocessing network. In addition, communication pertains to the capabilities the terminal offers to the student in terms of a user control language, message transmission features and stimulus generation. Finally, the control element refers to the methods of scoring and classifying student responses, and setting indexes for evaluation of the state of learning.[1] When designing a CAI program each of these elements should be considered separately; and yet the most effective courses will be those which integrate the content, communication and control features effectively into a smooth-running operation.

Aside from the technical and procedural considerations of CAI program design, certain more humanistic and psychological principles have been developed by University of Pittsburgh researchers. For example, instructional applications that use computer technology must always support the essential social characteristics of human learning. This principle refers to the emphasis upon defining the learning behavior first and then designing the technical application. As the development of CAI

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[1]Adams, "Technical Considerations in the Design of a CAI System," p. 264.

programs is a complex process, a sound supportive structure including educational theory, curriculum objectives, teachers and technicians must accompany the computer hardware and CAI software. It has already been noted that the effect of computer technology in education becomes much more profound when the student begins to exercise direct control over the machine and its functions. This theory arises frequently in current literature. CAI systems designers should avoid setting inflexible goals to accompany a set of rigid predefined objectives. The most serendipitous benefits of CAI are derived from those programs where new insights and experimentation are encouraged. Finally, these researchers have proposed that CAI designers preserve at all costs the intrinsic fun of engaging in dialogue with a computer. The technique will stimulate interest for other learning tasks if given a chance.[1]

Limitations of CAI Programs

It appears that there may be some limitations inherent in the nature of CAI programs or in the human - computer confrontation. After an evaluation of the research presented in the literature, three significant limitations have been noted.

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[1]Dwyer, "Some Principles for the Human Use of Computers," pp. 221-24.

The first limitation deals with the concept of the individualism of instruction. CAI programs have been successful in enabling each student to progress at his or her own pace; in providing a common starting point to a class of students who will then advance uniquely toward course completion. Yet this attempt to introduce individualism poses certain problems. One authority suggests that, "...the principal obstacles to Computer Assisted Instruction are not technical but pedagogical: how to design ways of individualizing instruction and designing a curriculum that are suited to individuals instead of groups."[1] Thus, it is not CAI that is the problem but rather traditional concepts about group education. Teachers and school administrators must be much more flexible in CAI-based curricula, inasmuch as specific objectives are more difficult to set and achievement is harder to measure. The traditional use of standard tests for all students in a group is not always valid in computer-based courses. New methods must be developed to overcome such obstacles.

A second limitation of CAI programs is related to a person's basic distrust of or lack of confidence in a machine. It is difficult for some people to overcome this uncertainty and approach an instructional CAI session with an open mind. They easily become overwhelmed by the mechanics

[1]Suppes, "The Use of the Computer in Education," p. 212.

of the process, although this can be due in part to a flaw in program design. Some designers attempt to enhance their program by introducing artificial variety into it, but this often results in confusing and frustrating the student.[1] It appears that the only way to overcome such feelings is to expose a person to an effective reliable CAI program. Again, this limitation to effective use of CAI programs is external to the process itself.

The final limitation pertains to the instructional capability of any type of programmed coursework. Can CAI be used to teach all subjects, and can CAI be used effectively to impart abstract concepts? Many authorities believe that most any subject material could be presented with the assistance of a computer. Yet it becomes apparent that this does not resolve the real issue. Every academic subject has within its domain a range of instructional behaviors and therefore requires a composite methodology of teaching. The type of behavior to be learned is of more significance than is the information content itself. This domain of behavior ranges from fact recognition, recall and knowledge of generalizations to comprehension, analysis, synthesis and inference.[2] The real issue then becomes to determine the extent of learning behavior to which CAI can

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[1]Adams, "Technical Considerations in the Design of a CAI System," pp. 263-64.

[2]Ibid., p. 265.

be applied. Research into several areas of heuristic programming has begun to demonstrate the broad range of behavior for which computers can be used. If a computer program can play a reasonable game of chess, can a similar program not also be used to assist a student to improve his business decision-making capability? It appears that it can but two things seem certain: first, CAI technology is still some years away from widespread use in conceptual behavior learning; and second, this delay will result from problems in behavior definition and from difficulties in measuring the extent of teaching effectiveness of those programs developed for research in this area.

Summary

There exist today two fundamental approaches to educational philosophy, humanistic and technological. At first these two theories seem to stand in opposition to each other but a compromise appears possible. Every sound curriculum must be based upon a set of general humanistic principles. Once these principles are established, specific applications of instruction can be developed using techniques such as CAI. As long as the applications reflect the intent of the general principles, computer technology can be used effectively.

Communication is one of the most significant factors to be considered in the design of CAI systems. To date there has not been a major breakthrough in the solution to problems associated with man-machine communication. Research has shown that the voice communication mode is the most effective one among humans and for this reason attempts are being made to develop natural language translations for computers. Some computers can now respond to limited human voice commands and many advances are expected in the near future.

All CAI systems can be considered as cybernetic systems since they deal with a repetition of student perception and response in a self-regulating mode. In a dialogue CAI program, the student and the computer alter as focal points in the cybernetic system. Some dialogue systems can be classified as generative. The most significant feature of a generative CAI program is its reasoning process which allows the computer to "learn." This learning process consists of building a model of the student, updating this model, acquiring new information by evaluating student response, and updating the old information. Technical design considerations of a CAI program consist of content, communication and control factors. Effective CAI programs integrate these three aspects into a unified application.

Another viewpoint is that of the humanistic or psychological approach to CAI program design. This approach proposes that: all CAI applications should support the essential characteristics of human learning; CAI programs need a sound supportive structure; student control of the computer program facilities is important; CAI-based curricula should be flexible; and designers must preserve the fun intrinsic to a student-computer dialogue.

Limitations in the successful application of CAI programs are related to problems of individualized curriculum development, to a person's basic distrust of and lack of confidence in the computer, and to the instructional capability of any type of automated teaching technique.

CHAPTER IV

ADVANCES IN REMOTE TERMINAL, TELECOMMUNICATIONS AND COMPUTER TECHNOLOGY

When computers were first used by students for educational purposes, most of the developmental effort was devoted to designing and improving Computer Assisted Instruction (CAI) programs. The characteristics of the computer terminal and the telecommunications link were considered secondary because there was relatively little variety in these facets of CAI system design. The earlier CAI systems consisted of one or more teletypewriter terminals accessing a nearby central processor through some type of direct communication line. During the late 1960's and early 1970's an entirely new technology has emerged which includes more sophisticated computer terminals, telecommunication lines and complex networks. This technology also includes extensive advances in miniaturization of electronic circuitry which has been used in new types of terminals, and which has enabled the design of mini and micro processing units. Significant developments in this technology will be examined to the extent that they might affect CAI programs, their effectiveness and their impact on business and managerial students in the near future.

Computer Terminals

> In a timeshared student environment the terminal is the computer to the student, because it is the terminal he sees, feels, hears and uses. Yet in terms familiar to the electronic minded, the student may be confronted with so much "noise" at the terminal that the educational "signal" he seeks...may all too often be buried.[1]

Authorities today consider it essential to evaluate in detail the characteristics of computer terminals to be used in a CAI system. Bitzer felt it so essential that he designed an entirely new type of terminal for his PLATO IV system so that the software's capability was not restricted by the terminal's limitations. This innovativeness is an example of the technology which arose during the late 1960's. Prior to this time a teletype terminal was the only type available. As late as 1971 the Teletype Corporation accounted for ninety per cent of the terminal market with its models 33 and 35.[2] Considerations in selecting a terminal include character sets, line speeds, printing capability and a diversity of special features. The teletype is still used in many systems because it is reliable and relatively inexpensive. Transmission rate of data is rather slow (thirty characters

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[1]Alfred M. Bork, "Terminals for Education," Educom (Winter, 1972):15, cited by Computing Newsletter, April 1973, p.2.

[2]Levien, The Emerging Technology, p. 279.

per second) and such terminals are limited in their flexibility. Certain manufacturers have adapted general purpose typewriters to fulfill the dual role of office typewriting and coupling to a computer for remote data processing. IBM's Magnetic Card Selectric typewriter is one such example.

A major breakthrough in the field of computer terminals occurred with the introduction of the first cathrode ray tube (CRT) screen. What is unique about the CRT is not its advanced technology but rather its application to computers, since a CRT is similar to the television screen introduced some twenty years earlier. CRT's are much more flexible than teletypes and their cost has been reduced continuously so that a basic CRT can be rented for under $125 per month.[1] A printer can be attached to the CRT to preserve selected displays for later reference. Another method of data retention is a tape cassette unit which can receive transmitted data or store it for later display on the screen. Transmission speed with a CRT becomes a function of the data set or modem available to the unit; speeds of 4800 bits per seconds (BPS or BAUD) can be achieved on existing CRT's. Communication with a CRT is no longer limited to keyboard typing but can be effected with a light pen or wand touched to the screen.

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[1] Chevalier and Gateau, Report on the Instructional Use of the Computer, 2:4.

A CAI student can point to a correct answer or draw a curve or figure in response to a computer stimulus. The CRT screen can also display previously stored visual information in vivid colors like a slide projector.[1] In summary a CRT is fast, colorful and flexible, allows data to be altered, and permits extensive graphic capability.[2]

This graphic capability introduced a new dimension to CAI systems. It has long been recognized that drawing pictures can be a useful way to demonstrate many concepts. Alternatively, students can effectively show their understanding of certain subject material by "drawing" a response to the computer. Three CAI systems now use computer graphics: PLATO IV, The Culler-Fried System and the Oettinger TAC System. The graphic input display technology is just beginning and will expand rapidly as competition becomes more intense. Currently the Tektronix 4010 CRT and Bitzer's Plasma Display Panel are the most popular graphics devices available.[3] The Plasma Display Panel contains a layer of many small pockets of gas which glow when a computer-controlled voltage is introduced. The student can change the states of the voltage and therefore alter the data with

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[1] Adams, "Technical Considerations in the Design of a CAI System," p. 257.

[2] Chevalier and Gateau, Report on the Instructional Use of the Computer, 3:15.

[3] Computing Newsletter, April 1973, p. 2.

a light pen. A great variety of colors are permitted by using layers of different gases.[1]

Over 312 different computer terminals are currently available from some 144 manufacturers.[2] The designer of a CAI system therefore has a multitude of features to consider when selecting terminals for students to use. The amount of research in this aspect of system design has increased considerably in the last five years.

Telecommunications Networks

Another area where the technology has and will continue to offer new possibilities for sharing educational programs across great distances is that of computer communications. It was in 1957 that the first attempt was made to transmit data from a computer over public communication lines. By 1971 one half of the traffic over public lines was data being transmitted to or from a computer.[3] The success of this idea has encouraged the formation of several companies to compete with the only prior public carrier, the Bell System. Data Transmission Company (DATRAN), MCI Telecommunications and Communications Satellite Company (COMSAT) are three major ones; Western Union has introduced a network

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[1]Levien, The Emerging Technology, p. 284.

[2]Datapro 70 (Delran, N. J.: Datapro Research Corporation, 1975), 2:70D-010-20a,21a,91a.

[3]Computer Yearbook, 1972, p. 115.

called Westar, and the computing giant International Business Machines (IBM) has its Systems Network Architecture (SNA) package.[1] The Bell System itself is expected to have in operation the Digital Data Service (DDS) by about 1978. All of these networks are responding to the annual thirty-five per cent increase in data traffic in the United States, which is expected to continue at this rate through 1985.[2] The significance of this continued growth in data transmission facilities is that computer assisted program packages should be available to a diversity of learning centers, and also commercially developed CAI systems will be more readily available. This technological improvement and increased competition will bring about substantial reductions in costs for using common carriers for data transmission.[3] (Figure 8)

In summary, this twofold impact of readily available data communication networks and reduced usage rates will lower the cost per student hour of use for CAI systems and encourage sharing of CAI packages.

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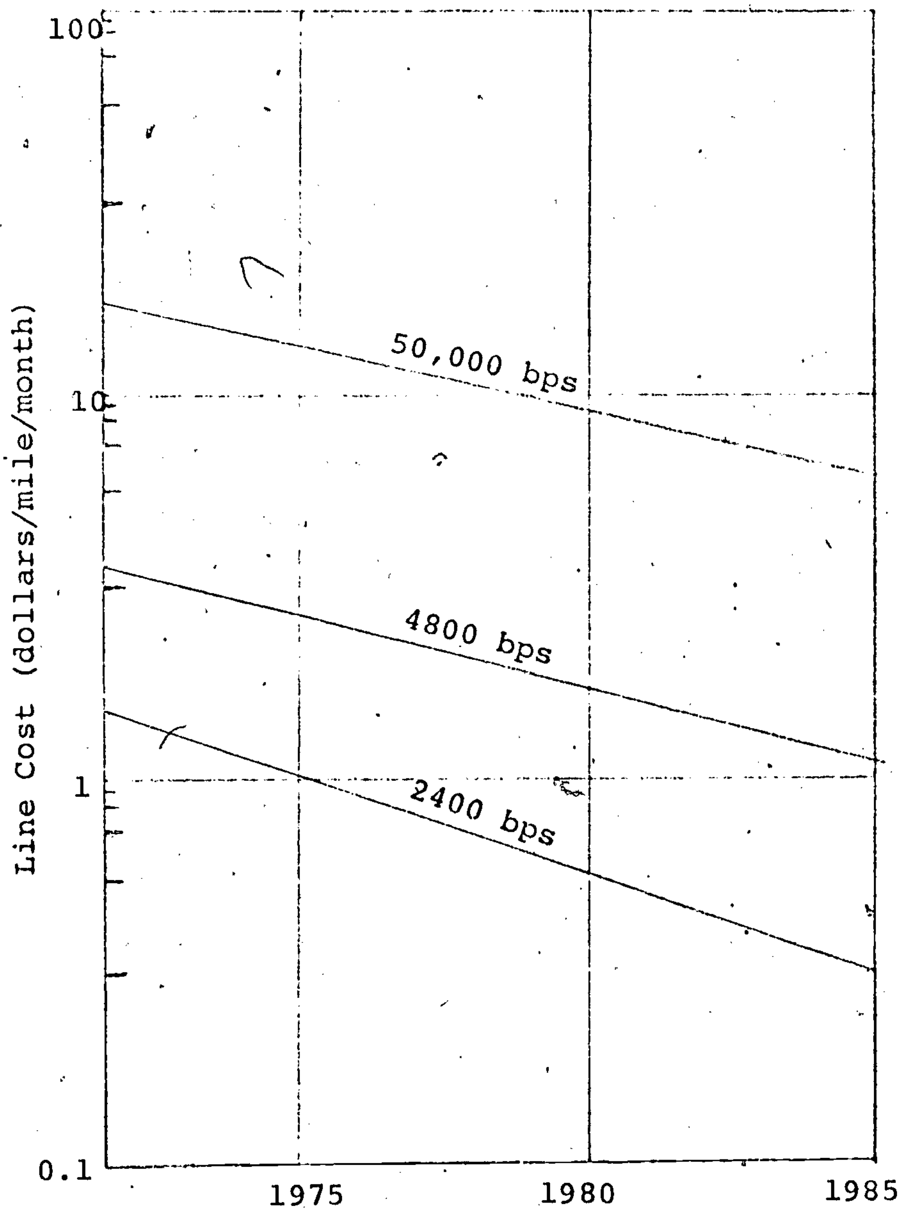
[1] Described in a series of four articles in Datamation, April 1975, pp. 45-56.

[2] Frederick G. Withington, "Beyond 1984: A Technology Forecast," Datamation, January 1975, p. 73.

[3] Ibid.

FIGURE 8

TELECOMMUNICATION LINE COSTS THROUGH 1985



SOURCE: Frederick G. Withington, "Beyond 1984: A Technological Forecast," Datamation, January 1975, p. 72.

Centralization versus Decentralization with Minicomputers

At the time the Digital Equipment Corporation (DEC) introduced the first minicomputer in the mid-1960's the trend in the computer industry was toward larger, faster and generally more costly machines. But since that time minicomputers have become an important factor in educational and scientific computing. DEC alone has delivered more than 26,000 units to date, and expenditures for minicomputers should reach one billion dollars by the end of 1975. This figure represents nearly ten per cent of the total market in the United States for computers and related services.[1] Currently fifty-four manufacturers offers 167 different models of minicomputers.[2]

Although there is no standard definition of what a minicomputer is, three characteristics tend to distinguish one from a more traditional computer: low cost, small size and lack of specialized environment. One authoritative source considers $50,000 as the upper purchase price limit of a unit to consider it a minicomputer. It is housed in a cabinet suitable for tabletop use or frame mounting and weighs less than fifty pounds. A minicomputer uses standard 115 volt electric power and requires no

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[1] Datapro Reports on Minicomputers (Delran, N. J.: Datapro Research Corporation, 1975), 1:M07-100-102.

[2] Datapro 70, 1:70c-010-20a.

special air conditioning.[1]

The significance of the proliferation of the minicomputer is that it will enable many more organizations and institutions to have access to computing power. Therefore, a small college which cannot possibly afford a large processor may be able to install a minicomputer and buy or lease CAI program routines developed at another school or commercially.

The minicomputer signifies the concept of decentralized processing and the proponents of this philosophy feel that this approach to computing will become dominant in the future. One fact tends to support this position: a study in 1960 predicted there would be 75,000 computers in use by the early 1970's; but by 1972, there were over 150,000 computers installed. And yet the trend in CAI development thus far has been toward large-scale centralized processing of a diverse time-sharing network.[2] These large systems use powerful computers such as the RCA Spectra 70, the IBM 370 and the CDC 6400, used by PLATO IV. Such large computers offer the advantages of massive storage capability and rapid processing cycles. Many CAI application programs can be available to students.[3]

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[1]Ibid, pp. 70c-010-20a-b.

[2]Chevalier and Gateau, Report on the Instructional Use of the Computer, 3:4.

[3]Ibid., p. 11.

There have been very few computers designed specifically for CAI application processing. The reason is that many of today's major computers can perform well the three functions needed to support a CAI system: execution/processing, data storage and telecommunication management.[1]

It remains to be seen whether minicomputers will have a substantial effect on CAI usage in the near future. The powerful centralized time-sharing system still dominates the university educational networks but new entries into the minicomputer field may effect this dominance. For example, IBM recently announced its System/32, described enthusiastically as "...programless, peripharelesss, memoryless and maintenanceless."[2] The entire system can be rented for less than $1,000 per month and is aimed at the vast number of potential first-time computer users.[3]

Perhaps some resolution of this question lies in the fact that System/32, like other new minicomputers, can also be used as an intelligent terminal tied into a large central computer. The unit can therefore act as an end point of a multi-user time-sharing system, or process data uniquely at its own location. Such units offer a flexibility not previously available.

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[1]Ibid., p. 9.

[2]Computing Newsletter, April 1975, p. 1.

[3]Datapro 70, 1:70c-491-25a.

System Configuration and Cost Analysis

Much of the analysis thus far has been of capabilities currently offered or anticipated in the near future relative to terminals, communications networks and central processors. A more practical aspect to consider is the cost of these components of a hardware system needed to support CAI software and students. Since prohibitive costs would tend to stifle CAI development and usage, it is significant to examine relative costs of different types of computer support systems.

Although there is an extensive number of possible hardware configurations to support students in a CAI terminal environment, they all fall into one of three general patterns. These include obtaining one's own large-scale computer and terminals; establishing a network of several minicomputers situated in strategic locations about the college campus; or time-sharing using commercially developed CAI software and computing facilities.

To date the major trend in the larger CAI applications has been to buy or lease a large central processor and establish a diverse terminal network tied into it.[1] costs associated with this type of application include the central processor itself, terminals, telecommunication lines and the CAI courseware. Specific costs for each of these

[1] Chevalier and Gateau, Report on the Instructional Use of the Computer, 3:4.

items may vary greatly from system to system depending on the type of terminals, the physical distance of terminals from the processor, and the volume and complexity of CAI programs.

By establishing a minicomputer network much of the cost associated with communications lines is avoided. Usually the terminals supported by a minicomputer are located in the immediate vicinity of the machine itself. The unit cost of each minicomputer is much less than for a large computer, so the number of minicomputers obtained will control the outlay for the central computing capacity. CAI courseware must also be paid for and programs in a minicomputer network will generally be less complex than in a large-scale system.

Commercial time-sharing CAI systems have begun to be developed in recent years and are often an outgrowth of smaller systems originally designed for single campus use only. The charge to use such a commercial system is usually based upon a standard cost algorithm which includes such variables as dial-up time, line usage, central processing time and storage requirements. Rates are usually quite reasonable and the user has at his avail all CAI courseware that the commercial agent has developed or purchased. The user is expected to provide his own terminals so this cost must be considered also. There are ten commercial CAI time-sharing networks described in the literature:[1]

a. Educational Information Network (EIN), which consists of over seventy smaller EDP centers.

b. Dartmouth Time-Sharing System, established by Dartmouth in 1973.

c. PLATO IV, described previously, developed at the University of Illinois; intended to serve 4,000 terminal users.

d. Educational Management Research Information System, developed by the Eastern Kentucky Educational Development Corporation; uses an RCA Spectra 70 computer and supports 3,000 pupils.

e. Network serving 192 terminals in the New York City area; uses an RCA Spectra 70 and costs $190,000 per year to operate.

f. The Southwest Regional Educational Laboratory in Los Angeles.

g. Sterling Institute network in Boston.

h. The University of Pittsburgh time-sharing system.

i. Hewlett-Packard system, which has commercialized courseware developed by Patrick Suppes.

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[1] Chevalier and Gateau, Report on the Instructional Use of the Computer, 2:7,8,11,13 and 3:27,42,59.

j. Westinghouse Learning Corporation's Program for Learning in Accordance with Needs (PLAN) System.

It appears that commercial CAI packages may become profitable so that competition should increase in the near future. As this happens, CAI courses will be available to a much broader number of students and cost of development will be spread over a larger base.

Cost and Capability Trends

Table 2 presents comparative data about potential costs and capabilities of computers in 1977 and 1985. There are three significant points which the data in the table supports. First, there are four distinct classes of computers. Smaller scale machines are subdivided into "micro" and "mini" categories, while larger computers are called "mono" and "multi" classes. The distinction of the two smaller types will result from greater specialization of circuitry technology. The "multi" class will permit true multiprocessing by joining two or more central units together for potentially vast computing capability. The second significant point is that costs in all categories will be reduced as much as fifty per cent. This cost reduction will be achieved as a result of technical advances and increased competition. A third noteworthy trend is that both main and auxiliary storage capacities will increase tremendously. For example, a 1985 model minicomputer may have as much as 500,000 bytes of main memory,

TABLE 2

FUTURE COMPUTER CLASSES

	MICROCOMPUTER		MINICOMPUTER		MONO-COMPUTER		MULTI-COMPUTER	
	1977	1985	1977	1985	1977	1985**	1977	1985
TYPICAL USE ON-LINE (USERS)	1 OR	5-10 OR	6-10 AND	10-20 AND	10-20 AND	20-40 AND	COMPLETE INTERMIXING. JOB DETERMINES LIMIT	
BATCH (STREAMS)	1	1	1	1	4-6	6-8		
MAIN MEMORY (BYTES)	4-8 KB	32-64 KB	32-64 KB	0.2-0.5 MB	0.5-2 MB	2-4 MB	2-16 MB	8-64 MB
BACKING STORE* (BYTES)	300 KB	500 KB	500 KB	4 MB	10 MB	30 MB	50-200 MB	100-500 MB
OPERATING SYSTEM	MINIMAL	MINIMAL	REAL, FIXED PARTITIONS	VIRTUAL	PARTITIONED VIRTUAL	VIRTUAL	MULTIPLE VIRTUAL MEMORY OR MACHINE	
USER COST (000)	$1-2	0.3-0.7	10-20	7-10	150-250	75-100	1.5-2.5	1-2

**THIS SYSTEM WILL PROBABLY HAVE MULTIPLE MAIN PROCESSORS BY 1985.

SOURCE: Frederick G. Withington, "Beyond 1984: A Technology Forecast," <u>Datamation</u>, January 1975, p. 56.

which is as much as some of the "large" IBM 360 systems. This expansion, accompanied by an absolute cost reduction will greatly increase the flexibility of minicomputers. At the same time, the multicomputer class will become so powerful that it is difficult to describe upper-limit capabilities. Associated cost reductions will continue to make the large computer popular in most markets.

Summary

Until recently, designers of CAI systems did not have to devote a great deal of time to evaluating capabilities of computer terminals because little variety existed. But around 1970 a new technology began to emerge which saw a proliferation of terminal types and capabilities. All early CAI systems used teletype terminals and as late as 1971, the Teletype Corporation supplied its models to ninety per cent of the entire computer terminal market. A major breakthrough in this area was the introduction of the cathode ray tube (CRT). Although CRT's were initially very expensive, advances in the technology and intense competition have enabled continual price reductions so that a basic CRT is now available for $125 per month. CRT's are fast, flexible, colorful and allow for extensive graphic capability. This ability to display graphic images has introduced a new dimension to CAI systems. Pictures can be useful in demonstrating many concepts and techniques, and students can also respond to the computer by drawing answers with a light pen. The Plasma Display Panel used in the PLATO IV System uses layers of ionized gases to depict images on the screen. There are currently 312 different models of terminals available.

Another area of technological advance is telecommunication networking. The first time computer data was transmitted over public carrier lines was in 1957, and by 1971 over fifty percent of public traffic was computer data transmission. Several new large companies have been established to handle the annual thirty-five per cent increase in data volume. The significance of advances in the telecommunications field is that transmission rates are being reduced so that standard CAI course work can be available to a great number of user installations.

Advances in circuitry technology have introduced the minicomputer as a new form of central processing unit. A minicomputer is characterized by relatively low cost and small size, and does not require a specialized environment. The use of minicomputers for CAI processing represents the method of decentralization. Inspite of the proliferation of minicomputers, the trend to date for most CAI applications is large centralized processors supporting a diverse terminal network. It is likely that minicomputers will be used as both end-point terminals and as stand-alone processors, allowing a flexibility not previously offered. This combination permits access to central CAI programs as well as local processing.

There are three general methods of establishing a CAI network: with a large processor and terminal network, with a network of minicomputers, or by commercial time-sharing. The costs of central processing involve the large-scale unit, telecommunications and courseware. With minicomputers the communications network can be eliminated. In a commercial system there is a cost algorithm used to charge customers. There are ten commercial systems described in the literature and more should be available.

There are three trends in the computer hardware area. First, four classes of computers will emerge: micro, mini, mono and multi categories. Second, costs for all types of computers will be reduced significantly. And finally, storage capacities will increase tremendously so that even the "smaller" versions will be very powerful.

CHAPTER V

CURRENT COMPUTER ASSISTED INSTRUCTION APPLICATIONS FOR BUSINESS AND MANAGEMENT STUDY

Introduction

One measure of the future usage of Computer Assisted Instruction (CAI) for business and management subjects is the extent to which CAI is currently being used in these fields. Therefore, an examination has been made of various CAI applications in many American university business schools. Three major sources provided the data for this analysis. First, recent literature was examined for descriptions and examples of CAI systems now in use. Second, a questionnaire was mailed to fifty business schools and colleges associated with some of the larger American universities. Third, Computing Newsletter's Third Triennial Survey of Computer Uses and Computer Curriculum in Schools of Business provided significant facts pertinent to this analysis.[1]

Subjects Under Consideration

The subjects pertinent to this study include those which might be included in the curriculum of a university

[1] Computing Newsletter, October 1974, pp. 1-5.

business school, such as: accounting, business mathematics, statistics, finance, economics, personnel administration, various courses in computer science, human behavioral theory, organizational theory, marketing and managerial decision making. The level of coursework includes material for both undergraduate and graduate presentation, as well as courses designed for practicing businessmen and managers. It is believed that courses intended to supplement a career development plan will frequently be offered in a university environment, or at least through a business school curriculum.

Simulation and Gaming

CAI can be defined in the strictest sense as computerized program routines which contain in themselves defined course material to enhance instruction of a student. In this regard, drill and practice, tutorial and dialogue applications comprise the majority of CAI programs. In a more general sense, CAI may include any type of educational process that uses computerized programs to enhance the teaching/learning cycle. According to this broader definition, an academic course in which students use some FORTRAN routines, for example, to assist in solving a problem presented in a classroom lecture is also considered CAI. Authorities differ as to which description of CAI is more accurate.

Another set of computerized tools that have been used extensively in business curricula are simulation and gaming. These techniques also are considered by some authorities to be in the realm of CAI. Simulation involves the representation of real-world phenomena in a computer by a series of mathematical or logical algorithms. The resultant structure is called a model. Gaming is a process in which a student and computer interact using a simulated model as a starting point. The student responds to a question or problem according to a set of rules; the model is revised, and the process continues until the game is over.

Computerized simulation and gaming techniques offer several advantages for classroom instruction. The student brings the "real world" to the terminal, examines and alters data under his or her own control and is in an open-ended discovery situation. The student can work individually and receives continual feedback as a result of his or her decisions. Learning is derived from motivation and the simulation environment appears to be interesting and motivating.[1] Certain limitations have been acknowledged in the simulation technique. It is frequently difficult for a designer to achieve that delicate balance between realism

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[1] Judith B. Edwards, "Simulation for Instruction: Some Considerations for Users and Designers," ACM Sigcue Bulletin 7 (April 1973):17-18.

and simplicity, and the designer's biases can easily be built in so that the model is distorted, even if unintentionally. Finally, most relationships in the social world cannot be accounted for systematically and caution should be exercised in drawing conclusions from model alteration.[1] In general, however, both designers and users are enthusiastic about simulation techniques, and it has been stated that "Either games teach, but we don't know why or games probably do not teach, but they do motivate."[2] Examples of games currently used in university business curricula will be described in the next section.

Current CAI Usage

A questionnaire was mailed to fifty business schools associated with large American universities in May 1975. Thirty-three completed questionnaires were returned; a list of these schools is contained in Appendix B, but all statistical analysis has been done without reference to individual schools. The purpose of the questionnaire was to discover a representation of CAI usage and to categorize some specific data about subjects and numbers of students using CAI in business schools. The questionnaire is contained in Appendix C.

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[1] Ibid., p. 19.

[2] Ibid., p. 23.

Table 3 contains the summarized results provided by the respondents of the questionnaire. In some cases the result is a total, while in others it is an average or range of all responses to a given question. An evaluation of significant findings follows.

Of the thirty-three business schools responding, fourteen said that CAI is used in their curriculum. The term CAI was purposely not defined so that the recipient could describe computer usage without being constrained by a narrow definition. Eight additional schools do not use CAI courses *per se* (in its narrower sense) but do use the computer as a tool for problem solving and simulations. One other school is just starting to use the PLATO IV System.

The earliest use of CAI for business subjects which was indicated is 1958, while the majority of schools (eleven) have used CAI only since 1968. Six schools have introduced CAI since 1970.

Although the average number of courses for which CAI was used is approximately thirteen, four schools use it for over twenty courses. The maximum at any school was indicated to be fifty, and one reply to the question was "many".

The average number of students using CAI at each business school (1,250) was raised substantially by

TABLE 3

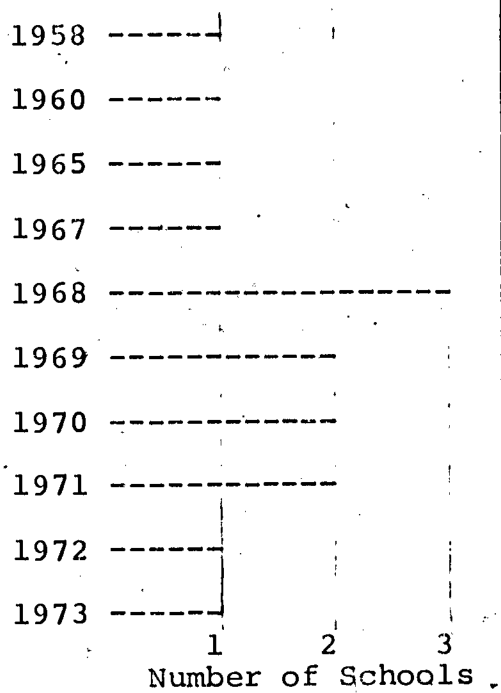
RESULTS OF QUESTIONNAIRE

Number of Schools Responding: 33 of 50 (66.7%)

Number of Schools Using CAI in Their Curriculum:

Yes - 14 No - 19 (Of these 19, 8 use computer as tool)

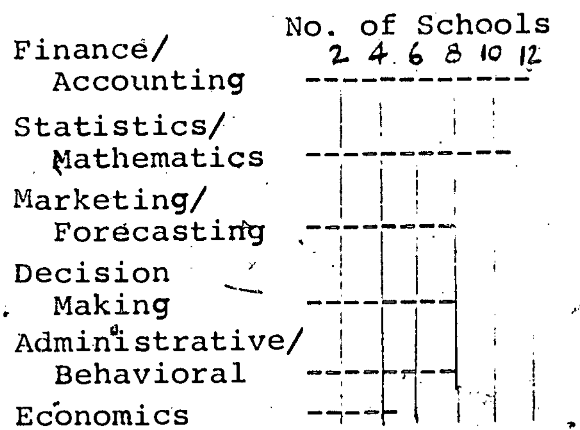
CAI First Introduced



Number of Courses in Which CAI Used

Number of Schools	Number of Courses
3	1 - 3
3	4 - 6
3	7 - 10
3	11 - 20
1	30
1	50
1	"many"

Fields in Which CAI Used



Number of Students Using CAI

Number of Schools	Number of Students
4	100-200
2	300-500
3	800-1000
2	1100-1200
1	2000
1	4000
1	5000

Processing Done on:

University's Own Computer - 13
State-Wide System - 2
Commercial Time-Sharing - 1

three schools reporting two thousand, four thousand and five thousand participating students. More schools were in the one to five hundred range than in any other related grouping.

The two strongest subject areas were finance/ accounting and statistics/mathematics. Economics was the lowest indicated but this is probably related to the fact that economics is often in a school of its own on campus. Thus, the business school representative may not be knowledgeable of CAI courses for economics. Two respondents cited this reason for not checking this subject area.

The overwhelming response to a question about the source of CAI programs indicated that almost all processing is done by each university's own central computer time-sharing system.

Four questionnaires contained comments which indicated that one key limitation to further development of CAI courses is the expense involved. Another indicated that "...the development of course material is quite time consuming, and provides little reward for the faculty." This person continued that, "In the past we have oversold CAI, and it will take a lot of time to overcome these past mistakes." A final caution was expressed as follows: "...the use of the computer in this fashion (using CAI in its most limited sense) has a long way to go before it becomes cost justified for most university-level topics."

In contrast to these cautions or negative attitudes toward CAI, one response was simply that it is "Indispensible." Another stated that, "CAI has a number of potentials for the improvement of educational quality." Four other questionnaires contained comments similar to this one, referring to anticipated benefits of CAI courses, for example:

> We have had computer aided gaming activity for research and teaching for many years. With the fall back in research funding we are in the process of increasing the teaching use of these facilities. Response to faculty and students has been enthusiastic.

In summary, it appears that although CAI programs are used in over forty per cent of the business schools which responded, most of the benefits of CAI are anticipated rather than already achieved. The greatest reservation appears to be cost of development, especially in terms of time involved. Of all thirty-three questionnaires returned only three contained no positive indicator about future CAI usage. It can be inferred that there will be significant growth in coming years. The extent and rate of development are difficult to predict.

The report on the Third Triennial Survey of Computer Uses and Computer Curriculum in Schools of Business provided an extensive series of facts and attitudes pertinent to CAI

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[1] Computing Newsletter, October 1974, pp. 1-5.

and simulation usage. Of 161 business schools queried, 118 replied. Perhaps the most significant finding was that in 1974, seventy-two percent of all schools required computer proficiency at the undergraduate level.[1] In 1966 only eleven per cent of schools responding required such proficiency. In 1970 barely one-half of the schools required computer proficiency at the Masters level, whereas in 1974 seventy-eight per cent did.[2]

Table 4 reflects the instruction methodology used to teach computer related subjects in business schools responding to the survey. Although only data processing courses are included in this table, it is likely that the statistics might be similar for other business fields. It seems significant that CAI was not used for instruction in more than five per cent for any subject group. Also, the more conceptual course material tends to be taught primarily by regular faculty members.

Because of this low CAI usage, statistics for factors inhibiting effective computer use in education were examined. (Table 5) The two greatest inhibitors both related to hardware capacity and availability. Lack of faculty interest was also

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[1] Most of the findings in this survey pertain to the use of computers for all educational purposes: CAI, simulation, computer programming, etc. It is felt that, although they are very broad in concept, the findings are extremely valuable to this thesis.

[2] Computing Newsletter, October 1974, p. 1.

TABLE 4

METHODS OF TEACHING COMPUTER SUBJECTS

(PER CENT OF SCHOOLS TEACHING THESE SUBJECTS)

	Method of Instruction					
Subject	Graduate Assistant	Regular Faculty	Computer Staff	Programmed Instruction Text	Computer Assisted Instruction	Films/ Video
Data Processing Concepts	21	55	11	3	3	7
Programming	27	48	10	5	5	5
Systems Analysis/Design	8	75	6	2	2	7
Simulation	3	81	3	7	3	3
Management Information System Concepts	3	78	3	5	3	8

SOURCE: Computing Newsletter, October 1974, p. 4.

TABLE 5

FACTORS INHIBITING EFFECTIVE COMPUTER USE IN INSTRUCTION

1974		1970	
Inhibitor	Weighted[1] Value	Inhibitor	Weighted[1] Value
Insufficient number of terminals	18.5	Lack of interest by faculty	18.5
Inadequate turnaround	18.2	Restricted budget for computers	12.7
Lack of interest by faculty	13.5	Unavailability of proper type of computer	7.8
Inadequate training of students	13.2	Lack of budget to train faculty	5.1
Lack of staff to implement programs	10.0	Lack of library routines	2.0
Shortage of teaching packages	4.2	Lack of interest by administration	1.9
Lack of interest by students	1.8	Lack of interest by students	.7

[1]This number represents a relative ranking based upon an overall evaluation of comments and answers from the survey. The values from 1974 should not be compared with those from 1970, only with the ones in the same column.

SOURCE: Computing Newsletter, October 1974, p. 5.

significant but this factor has subsided since 1970 when it was the greatest inhibitor. There was a noticeable lack of factors relating to cost, which appeared in two different forms in 1970. Relative to faculty orientation to computers, Table 6 indicates that virtually all development of computer-based educational packages by faculty was done in only one-third of the business schools and colleges. In over eighty per cent of the schools, fewer than one-half of the faculty even used computer teaching packages. It is evident that lack of knowledge or interest by faculty members, although decreasing, is still a limiting agent. Because many more current graduate business students will have a working knowledge of computers, this factor should decrease substantially.

The schools of business made substantial use of the campus computer compared with other schools and colleges of the university. (Table 7) In nearly three-quarters of the universities involved in the survey, the business school was ranked as the first, second or third largest user on the campus. It also seems significant that in 1974, seventy-five per cent of the business schools had access to time-sharing services provided by their own university computer; while in 1970 this ame factor was only

TABLE 6

FACULTY ORIENTATION TO COMPUTERS

(OF SIXTY-SEVEN SCHOOLS)

	Per Cent of Schools Where Faculty	
Per Cent	Develop Computer Based Packages	Use Computer Based Packages
0-10	66	7
11-20	28	16
21-30	5	28
31-40	1	21
41-50		10
51-60		9
61-70		6
71-80		3

SOURCE: Computing Newsletter, October 1974, p. 2.

TABLE 7

COMPUTER USAGE:
COMPARISON OF SCHOOLS OF BUSINESS
TO OTHER CAMPUS USERS

Rank among All Campus Users	Per Cent of Schools
1	23
2	22
3	27
4	11
5	6
6-10	6
Less than 11	5

SOURCE: Computing Newsletter, October 1974, p. 3.

forty-three per cent.[1] Only three per cent of the schools used off-campus commercial time-sharing in 1974. These facts all tend to support the trend toward centralization of academic computing on a large processor. In spite of the acquisition of more hardware, Table 8 shows that the amount spent for the computer and related services was in almost all cases less than fifteen per cent of the entire university budget. This seems to be a very reasonable sum to pay for campus-wide availability of CAI courses and computing facilities.

Examples of Existing CAI Systems

Several examples of CAI courses and programs used for business applications are described in the literature. Dartmouth's Amos Tuck School of Business has recently announced a number of new innovations. This school has long been a leader in CAI development, as far back as the introduction and design of the BASIC programming language. The Business School has greatly expanded its library of programs, and has procured faster terminals with graphics capability. Several of these have been placed in student dormitories for easy access. Every incoming business student receives one week of formal training in the Dartmouth Time Sharing System. Finally, a new data base

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[1] Ibid., p. 4.

TABLE 8

COMPARISON OF COMPUTER BUDGET
TO TOTAL BUDGET

Per Cent of Schools	Computer Budget Per Cent of Total
10	Less than 1
18	1-2
35	3-4
23	5-9
12	10-14
0	15-19
2	Greater than 19

SOURCE: <u>Computing Newsletter</u>, October 1974, p. 3.

containing information about stocks, commodities and mutual funds has been established for use in investment courses.[1]

The City College of Chicago has developed a basic accounting course using the PLATO IV System and the TUTOR language. Students use a CRT display without a printer because designers felt it is better to practice using new problems rather than repeating old ones. Arithmetic errors entered by a student are corrected immediately to avoid chain reaction mistakes. The student is allowed to enter answers in the form of arithmetic expressions, which PLATO will convert to numeric data. To date, teachers estimate a five per cent increase in learning achievement with approximately ten fewer hours of homework by a student.[2]

The University of Kansas has designed a CAI course for systems accounting, using a language called CODE. Initially, a statement of financial position for a company appears in the upper half of the CRT screen. This statement remains there throughout the lesson. Then an event is described in three lines or less; the student keys in the appropriate accounting entry based on the event. The entry

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[1] Computing Newsletter, March 1975, p. 2.

[2] Computing Newsletter, November 1974, p. 4.

is then evaluated by the computer (programs) and a response is returned to the student indicating the correct answer or reinforcing the correctness of the student's answer. To complete the cycle, the program updates the original financial statement with the revised information and a new event is described. The student's performance is continually evaluated by another program routine.[1]

Florida State University has developed a CAI course for concepts of business data processing. Over 750 students have taken the course. Not only do the programs present the subject material, but they also generate quizzes which are unique and random. The course is administered by one full-time professor and six assistants for 250 students per quarter.[2]

The University of Notre Dame has written a course to teach principles of economics. The material is based on Paul Samuelson's widely used textbook and covers two semesters. The course is available to other institutions for only twenty-five dollars.[3]

Summary

CAI can be defined narrowly to include only self-contained interactive program routines or more broadly

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[1] *Computing Newsletter*, November 1974, p. 2.

[2] *Computing Newsletter*, November 1974, p. 2.

[3] *Computing Newsletter*, March 1975, p. 3.

to consist of all computerized tools to assist students. The techniques of simulation and gaming fall in this latter category and are used extensively in business school curricula. These techniques allow the student to bring the "real world" to the computer and to modify it in an open-ended discovery situation. Although the designer's biases are sometimes inadvertently built in, most students and teachers have been enthusiastic about the motivational benefits of simulation and gaming.

A questionnaire returned by thirty-three business schools provided a number of statistics and attitudes about CAI usage. Fourteen used CAI in their curriculum, eight used the computer as a tool for problem solving, and one was about to begin using PLATO IV. Only three of the questionnaires failed to cite positive indicators about current or future CAI usage. Most of the benefits appear to be anticipated rather than already achieved.

The report on the Third Triennial Survey of Computer Uses and Computer Curriculum in Schools of Business also revealed pertinent facts. It is significant that in 1974, seventy-two per cent of the schools responding required computer proficiency by their students. However, CAI programs were used by only a small percentage for teaching data processing courses and the more conceptual material was taught primarily by regular faculty. The trend in CAI processing was toward centralization of academic computing on a large processor on the university's own campus.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Computer Assisted Instruction (CAI) was first used as an instructive tool in the early 1960's, resulting from research into automated teaching techniques that began in 1920. During the last ten years American universities have developed such a large number of CAI courses that the technique may soon have a significant influence on higher education.

Authorities are divided in their opinions about the extent to which CAI will be used in the next several years. Proponents of CAI envision a tremendous increase in CAI networks and an extension of CAI teaching methods to all educational levels. They believe that advances in computer hardware and in terminal and telecommunication technology will enable CAI courses to be offered extensively at a tremendous reduction in cost. More conservative authorities, however, believe that CAI has been oversold and will not prove to be a major teaching method for many years to come. Course development they believe is too time-consuming and, therefore, too expensive. Also, CAI has several other limitations which will seriously restrict its use.

In spite of these differences of opinion, the research on CAI has raised significant questions about the individualism of instruction. Traditionally American educational philosophy has been primarily concerned with instructing groups of students simultaneously from a common starting point and with group goals. Effective CAI, on the other hand, is based upon the principle that each student has unique intellectual strengths and weaknesses, and that the instructional technique should be flexible enough to accomodate these differences.

Among the subject areas for which CAI courses have been developed are those of business and management. These fields include courses that are contained in a business school curriculum such as accounting, data processing, statistics and policy making. Because of the increasing scope and complexity of a manager's role in today's business or government organization, it is increasingly essential that business students have a working knowledge of several disciplines. To satisfy this need, more efficient teaching methods are required. Therefore, it appears that CAI might be a useful and more effective teaching method in the development of for the varied business curricula of today's schools and for the broadening career development courses of today's practicing managers.

This study has attempted to evaluate CAI and to explore the feasibility of using that technique for business and management course studies in the near future. In order to accomplish this evaluation, the following research question was addressed: "To what extent will Computer Assisted Instruction (CAI) be used in teaching business and managerial courses at the university and professional level during the next five to ten years?" The approach to answering this primary question involved the exploration of answers to several related subsidiary questions.

The first subsidiary question concerned an examination of the major trends in the development of CAI concepts and techniques. Although CAI is a relatively new instructional tool, many teachers and most students have received CAI with considerable enthusiasm, and many university educators have conducted research to identify the potential this technique may offer. To date, CAI usage has been rather limited, but each year the number of applications has increased. Although a substantial number of applications are still of the drill and practice category, most authorities believe that CAI can become significantly more effective as student control over the program increases. From an economic standpoint, the most significant cost factor will be course development and design while the associated hardware costs will continue to decrease.

An examination was made of the major subject areas where CAI has been applied. So far, CAI applications have been used primarily for drill and practice purposes in mathematics, for word usage, and for technical training. Recently, however, educators have employed CAI programs in complex mathematics courses, in scientific experiments, and in medical diagnosis. Conceptual courses such as law, education and business theory have also used CAI. Although designers have applied this technique at nearly every level of education, the principal developmental efforts have occurred at universities because of the availability of computers.

Psychological factors that are involved in the development of CAI courses were also studied. Since the learning process is structured around the alternating response and feedback between the student and the computer, communication is the most significant factor in effective CAI design. To date, there has been no major breakthrough in man-machine communication, although some important research has been done in the field of voice communication and much more is expected in the near future. All CAI systems can be considered as cybernetic systems since they deal with a repetition of student perception and response in a self-regulating mode. It is essential that CAI support the basic characteristics of human learning, that students exercise substantial control over programs, and that designers strive to preserve the intrinsic enjoyment involved in participating in computer dialogue.

What are some limitations encountered in developing and offering CAI? One limitation results from the conservative attitudes which many teachers have about the individualism of instruction. A second limitation involves a person's inherent distrust of a machine such as the computer, especially when it used for intellectual purposes. Experience has shown that increased exposure to CAI systems that are effective will tend to reduce this distrust. Finally, some authorities have questioned the instructional capability of CAI programs. It appears that CAI can be used effectively for almost any academic subject, but the type of behavior to be learned is a more important consideration. CAI is still some years away from widespread use in conceptual behavior learning. It seems that this delay will result from problems in behavior definition and from difficulties in measuring the teaching effectiveness of CAI.

Another question sought to explore the technological trends in computer hardware and terminal design, and to evaluate their effect on CAI program usage. During the 1970's there has been a proliferation of cathode ray tube (CRT) terminals made available which are fast, flexible, colorful and, most importantly, inexpensive. Terminals can also support extensive graphic capability which makes them useful to many other CAI applications. As of 1971, over fifty per cent of the traffic being transmitted over public communication lines was computer data. Several new companies have been formed to handle the annual thirty-five per cent increase in data transmission. As a result, transmission rates will decrease substantially, and extensive networks will be available so that centrally designed CAI courses can be accessed by many remote facilities. Finally, minicomputers may have a place in future CAI processing but the overwhelming trend so far has been toward a large-scale central processor serving a diverse terminal network. The most successful systems, such as PLATO IV, have used this latter concept.

The final subsidiary question attempted to measure how extensively CAI has been used in university business and managerial courses to date. Most of the business schools surveyed use the computer to some extent, although only a relatively small percentage of courses use CAI in the strictest sense. The majority of computer usage has been for simulation, gaming and general problem solving. Such usage has increased substantially in recent years for in 1974, seventy-two per cent of American business schools required computer proficiency of their students. This figure is significantly higher than in prior years. Most business schools are enthusiastic about CAI, but most of the benefits seem to be more anticipated than already achieved.

In conclusion, therefore, it appears that during the next five to ten years CAI can be reasonably expected to become a more significant tool in the conduct of university business and managerial courses. It seems reasonable to estimate that the current five per cent CAI usage may increase to fifteen or twenty per cent, based upon recent growth trends. This increase is likey to occur in well-structured subject areas such as statistics, accounting and computer programming. It appears that conceptual subjects will be taught primarily by more traditional methods in the near future. There will probably be much greater use of related computer instructional techniques such as simulation and gaming, and within ten years it is likely that <u>all</u> business students will be proficient with computers. The key factor in the extent to which CAI development will occur is the attitude of people, including school administrators and educators, since all other costs associated with CAI design and application should diminish substantially.

APPENDIX A

GLOSSARY

Adaptive program - A generalized computer routine which is designed to alter its logic paths based upon responses provided to it. The program direction itself is not planned in advance, but the criteria for response analysis and logic decision are. This type of program can effectively provide unique learning experiences from a common starting point.

Algorithm - A pre-defined set of rules, frequently pertaining to mathematical procedures, which will process an input or response datum in a precise manner. Often a computerized model will contain several such frameworks for processing varying inputs.

Artificial intelligence - The process of learning associated with a computer or computerized set of program instruction routines. This concept is still under extensive study by psychologists and computer experts.

Author language - A high-level computer language designed specifically for use in Computer Assisted Instruction programs. As the name implies, a course designer or teacher can write lessons with such a language; but this is also the medium of communication for the student.

Branching - A technique used in instructive programs that allows for alternative or looping paths in the logic depending upon the student's response. Sometimes called conditional branching. Contrast with linear.

Cathode ray tube (CRT) - A type of remote computer terminal frequently used in Computer Assisted Instruction which displays data on a television screen to the student or teacher. Graphics and color projections are possible using a CRT. Sometimes called a Video Display Unit (VDU).

Computer Assisted Instruction (CAI) - Any type of educational process that uses computerized programs as an enhancement to the teaching/learning cycle. Also called Computer Assisted Learning (CAL), Computer Aided Learning (CAL), Computer Based Instruction (CBI), and Computer Based Learning (CBL).

Computer Managed Instruction (CMI) - The process in which many of the administrative functions of education are performed with computer assistance. Functions include curriculum development, test preparation, achievement rating and student response pattern analysis. CAI and CMI are frequently used to complement each other.

Cybernetics - The science which deals with the study of systems and communications, with emphasis on the continuing process of action - feedback - adaption. Has dealt with the human nervous system in an attempt to explain the nature of the brain.

Dialogue - An instructional mode in CAI systems in which the computer and student appear to be engaging in a conversation. The program feedback is based upon student response. Also called the Socratic method of instruction.

Drill and practice - An instructional technique used in CAI to offer a student an orderly way to master various facts or patterns like arithmetic functions, spelling and word recognition.

Dual mode - A level of sophistication in CAI usage at which the student needs direct prompting from the computer to effectively learn material. A term coined by Dwyer; contrasted with solo mode.

Evaluation - The process by which programs associated with CAI courses analyze individual student responses, develop and store data patterns about the student, and control the rate at which the student advances in the course material.

Event processing - Technique by which computers use symbolic data to represent real-world phenomena, and provide feedback when these data are changed. Related terms are simulation and gaming.

Gaming - A process in which a student and computer interact using a simulated model or problem as the starting point. After the rules or criteria of the problem are presented, the student responds with an answer or set of changes to the model; the revised porblem is then presented and the process continues until the game is over.

Generative program - A computer routine used in CAI which can formulate questions and responses based upon general principles rather than on pre-defined detailed specifications.

Heuristics - The use of any method or strategy used to improve the efficiency of a system in attempting to solve complex problems. Heuristic computer programs have been developed to play chess, engage in card games and prove mathematical theorems. Related to artificial intelligence.

Learner-controlled - In CAI, an environment in which the student has at his avail the computer and various software routines, but where the direction of learning effort must be defined and executed by the student.

Light pen - An electronic device that looks like a writing utensil which is connected by wire to a cathode ray tube terminal. When touched to a specific spot on the screen, an electronic signal is passed to the computer to record a response. The light pen is an alternative method of student-terminal communication (vs. typewriter keying).

Linear - A technique used in early CAI programs in which the logic does not allow for alternative paths if responses are different. Contrasted with branching.

Natural language - One spoken by people (such as English or Russian), as opposed to any of the computer program languages currently available. Much research is now underway to enable computers to interpret natural human voice communication and provide a translation to another language.

Plasma display panel - A specialized computer terminal, developed by Bitzer for PLATO, that uses layers of ionized gas between two glass panels as the display medium. Extensive graphics and colors are possible.

Programmed Instruction (PI) - The process of using any kind of automated learning techniques, including but not limited to computers. CAI is one type of programmed instruction method.

Simulation - The representation of real-world phenomena, called a model, by an interrelated series of mathematical or logical algorithms. Frequently created using numerical symbols in a computer. This technique enables the student to see and experiment with processes that might not be available to them except in the computer.

Solo mode - A level of sophistication in CAI usage at which the student can work more or less on his own in writing computer programs to assist him in learning some set of material. A term coined by Dwyer, contrasted with dual mode.

Traditional Classroom Instruction (TI) - The mode of education in which computer technology is not used to assist in the teaching/learning process. Contrasted with CAI and CMI.

Tutorial - A type of CAI system in which the computer assumes the main role in the teaching process. The computer acts as a tutor and guides the student to the appropriate material at the proper rate of advancement.

APPENDIX B

Schools of Business Administration or Management Associated with the Following Universities That Responded to the Questionnaire

Arizona State University
Brigham Young University
California State University at Long Beach
Columbia University
Cornell University
Georgia State University
Indiana University
Massachusetts Institute of Technology
Michigan State University
Northwestern University
Ohio State University
Pennsylvania State University
Southern Illinois University at Carbondale
Stanford University
State University of New York at Buffalo
University of Alabama
University of Arkansas
University of California at Berkeley
University of California at Los Angeles
University of Connecticut
University of Florida
University of Georgia
University of Illinois
University of Kansas
University of Maryland
University of Michigan
University of Minnesota
University of Nebraska
University of Southern California
University of Texas at Austin
University of Washington at Seattle
University of Wisconsin at Madison
Washington University at St. Louis

APPENDIX C

May 4, 1975

Dear Sir:

I am a student in the Graduate School of Government and Business Administration at the George Washington University in Washington, D.C. As part of my M.B.A. requirement I am writing a thesis entitled, "Computer Assisted Instruction for Management and Business Study: a Look to the Future." I am interested in determining the extent to which Computer Assisted Instruction applications are currently being used in university business curricula. To help me in doing so, I ask you to complete the brief questionnaire I have developed and return it to me in the enclosed self-addressed, stamped envelope.

Because of my time deadline, I would appreciate if you could return the completed questionnaire by June 2, 1975. Thank you very much for your cooperation.

Sincerely,

Daniel J. Sullivan

QUESTIONNAIRE ON USAGE OF COMPUTER ASSISTED INSTRUCTION (CAI) IN UNIVERSITY BUSINESS CURRICULA

1. Name of University/School ______________________________

   ____

2. Is CAI used in any part of your curriculum? _____Yes

   _____No

3. If so, when was CAI first introduced? ________(Year)

4. In approximately how many courses is CAI used? ________

5. Approximately how many business students use CAI? ________

6. In what fields is CAI used? (Check appropriately)

   _____Statistics/Mathematics

   _____Economics

   _____Marketing/Forecasting

   _____Finance/Accounting

   _____Administrative Theory/Behavioral Science

   _____Decision Making

   _____Other (Please specify) ______________________________

   ____

7. Is processing done on: University's computer______

   Time-sharing (Commercial)______

8. Please comment on your attitude toward CAI or about its potential at your University/School (Continue on reverse if necessary).

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