AN INNOVATIVE AND GROWING MASS DELIVERY SYSTEM: COMPUTER-BASED INSTRUCTION

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ABSTRACT

This is an attempt to investigate the rich array of computer applications that can make education more effective and efficient. Computers can basically be used for two major purposes in education: one, administration and two, instruction. In instruction we can distinguish four different functions: instruction about computers, computers as means of instruction, computers as enrichment of instruction, and computers for management of instruction.

Different types of computer usage in The United States education are dealt with thoroughly. An analysis of different types, hopefully will give some insights of what could be done in Taiwan.

摘　　要

電腦日益普及，近年來運用在教育上已經有了很大的效果。電腦在教育上的運用，一般大別爲兩類：一是行政，二是教學　。本文詳述電腦在教學上的用途，計分電腦輔助教學。（CAI　）、電腦管理教學（CMI　）、電腦促進教學、電腦硬體和軟體的教學，特別着重電腦輔助教學和電腦管理教學兩項，深入分析電腦在教育上的各種發展、現狀與用途，希望透過探討美國教育界使用電腦的經驗，作爲我國教育界日後運用電腦的參考。

INTRODUCTION

As prices go down, it is expected that computers will have more and more

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impact in the near future. It is anticipated that the computer industry will be the largest industry in the world (Davis, 1974). Tomorrow, the computer will be a more and more integrated part of the modern world. We now already have a forerunner of it. Everybody in the U.S. already gets accustomed to the punched card pay check and bills for power, gas, insurance and others. As a matter of fact, most government offices and industries could not function without computer support. This would be especially true for the Internal Revenue Services and most of the large corporations in the U.S. Computers are also used by the Armed Forces, by the police for traffic control and car census, by the public and commercial weather forecasting and by various industries, like flight planning and seat reservation at the airports. The banking industry also makes more and more use of the computer for management, accounting and inventory control.

In this expanding computer world, it is rather striking to notice that education, one of the largest institutions in our country according to the allowed budget, continues operating quasi without taking the full benefits of the potential of computers to raise the quality and efficiency of administration and instruction. It is the purpose of this paper to examine what role computers could play, especially at the teaching and learning aspects of school activity. In order to get insight into their potentialities, an investigation is made of their use in the area of education in the United States.

Computers in American Education

Computers in American education are basically used for two purposes: for administration and for instruction. At the university level, research has to be added as a third computer supported educational activity.

In higher education, for the academic year 1969-1970, the distribution of expenditures for uses of computers was estimated at 34% for administration, 32% for research, 30% for instruction, and 4% for services to other institutions and industry (Hamblen, 1977).

In secondary education in 1970, 34% of the schools already used computers. Of those users, 63% used the computer for administrative purposes only, 11% for instructional purposes only, and 26% combined both uses. Computer support in education is expanding considerably. In 1975, there was an increase of 24% in users in secondary education giving a total of 58%. The figures of 1975 also showed a trend to a more balanced use. Unilateral use for administration dropped to 54% and for instruction to 8%, while combined use increased to 38% (Darby, 1972 and Bukoski, 1976). The same trend was shown in higher education. Where 12% of computer use was devoted to administration only in 1967, this was only 10% in 1970, while multipurpose use for research, administration and instruction increased from 53% to 61%.

The use of computers at grade school level is also continuously increasing. Unfortunately, figures to demonstrate this expansion were not available.

The core of this study will primarily be confined to the instructional use of computers.

Computers in Instruction

In addition to the administrational use of computers, an increasing number of schools have turned to the use of computers for instructional purposes. A distinction can be made between the use of computers for the preparation of computer personnel, in computer sciences and training in Electronic Data Processing (EDP), the use of computers as means of instruction or delivery system in the so-called Computer Assisted Instruction (CAI) and the use of computers as adjunct or enrichment of instruction in a variety of applications. The computer can enrich the learning environment in applications for problem solving, inquiry, simulation and learning games. However, the general term CAI also applies to these areas. Another major application of computers in instruction is for the management of the instructional process or computer managed instruction, or CMI (Lau, 1976b).

As for the subject matter or courses where computers are involved, surveys in higher education (Hamblen, 1977) and in secondary education (Bukoski, 1976) show a predominant use in science and mathematics, with a high percentage for computer science. In 1975, the U.S. secondary schools used computers 43% in mathematics courses, 22% in computer science, 16% in sciences, and 3% in business education. At the university level, in 1970, 28% went to engineering, 18% to computer science, 13% to business administration courses, 11% to mathematics and statistics and 9% to sciences. Social sciences and language instruction make less use of computers. At the secondary level, 5% is used for vocational education, 4% for social sciences, 2% for languages and 4% for miscellaneous courses and independent work. At the university, 9% of the courses involving computer usage in 1970 were social sciences, 2% education, and 10% other areas of instruction.

In the remainder of this paper, different uses of computers for instructional purposes will be reviewed with a special emphasis on CAI, simulation and games, and CMI.

Instruction as to the Utilization of Computers

As mentioned above, a major application of computers in instruction is made in computer science and data processing courses. In our country it is believed that, this is for the moment, the almost exclusive use of computers in the active learning process.

Computer science and data processing courses are concerned with basic functional computer literacy. Topics are the study of computer hardware (i.e., the machinery), its components and their function, operation systems, computer software (i.e., computer programming) and information processing. This kind of instruction assures technical career training in computer programming, operation, and service technicians. Systems analysts are prepared to analyze information requirements of organizations and to design and develop information systems to provide that information in the right form. Programmers learn to write programs in different computer languages such as assembly, FORTRAN, COBOL, PL/1 and others. They have to run their programs on the computer and debug them (i.e., make them error free). Keypunchers are trained for input data preparation. Machine operators manipulate tape drives, card readers, printers, and are responsible for file maintenance. The computer services technician is the person who is called upon for installation and maintenance of the CPU and the input/output devices.

The future for careers in information processing is promising. One of the fears that computers would cause unemployment seems to be untrue, conversely computers lead to creating numerous new work opportunities. As the computer industry is steadily increasing, a parallel need for computer people can be expected (Davis, 1974).

COMPUTERS AS MEANS OF INSTRUCTION: CAI

Besides learning about computers, schools also organize learning with computers. When the computer becomes the tool of dissemination of instruction, we are concerned with Computer Assisted Instruction (CAI).

Concepts

CAI is an instructional delivery system where the learners are presented with the learning material and interact with it at a computer terminal. Different labels have been given to this learning strategy: Computer Assisted or Computer Aided Learning (CAL), Computer Supported Instruction (CSI), PLATO Assisted Learning (PAL) and Computer Based Instruction (CBI).

The term CAI on its own covers three different modes of instructional strategy:

tutorial, drill and practice, and dialogue.

Tutorial can best be compared with computerized learning. Indeed, it is an outgrowth of the early teaching machines or automated learning devices based on programmed instruction.

Due to the lack of adaptiveness to the individual needs of the learner, the teaching machines served as earlier models in the development of CAI of this type (Gleason, 1971). In tutorial, through the terminal screen (like the ordinary TV set) new information is presented to the learners and followed by a question. Students type in or touch the screen of the terminal to indicate their answers and receive immediate feedback from the computer; correct or incorrect, good or try again, etc. The student then advances or is branched to some more information or to repeat the previous material before continuing.

Drill and practice is a form of CAI in which the students are given exercises of skill in previously learned material given in a lecture or instruction delivered by the computer. This mode helps students to memorize facts and concepts and master basic skills through repetition. The computer guides and monitors; it checks answers and corrects answers. There is no new instruction involved.

Dialogue, also called socratic, is the most sophisticated kind of CAI. While tutorial and drill and practice are completely author-control, dialogue provides more learner-control. Instruction is provided in a question-answer fashion where students are forced to reason for themselves (Kearsley, 1977).

The student can initiate questions and the computer is programmed in a way that possible answers are anticipated, interpreted and branching takes place accordingly. Although it has potential, it is still greatly in the experimental stage (Rockart, 1975).

Aims and Objectives of CAI

"CAI activity is dedicated to the belief that individualized instruction is a desirable and important educational goal and further, that the computer delivery of instruction is a very effective means of achieving this goal" (Kearsley, 1977, p. 20).

As a matter of fact, CAI is designed on the Skinnerian theory of learning on behavioristic bases. CAI as an extension of programmed instruction is founded on the principles underlaying this theory. The principles are: the student's active response, reinforcement by feedback of results or corrective action, and self-paced learning activity. Providing learning in accordance with needs and capacities of the individual student are premises. The emphasis is obviously more on learning than on teaching. Major advantages of CAI over programmed instruction are adaptive (Lau, 1978, 1979a) and response-sensitive through branching possibilities and a "cheat-proof" system. Compared with all other teaching strategies, CAI is certainly the most flexible one.

Audiences

For what learners is CAI intended? CAI is very versatile regarding the different levels of education. Courses are designed for students from elementary through graduate level and for adult education and professional training. CAI seems to be particularly appropriate for slow and disadvantaged students (Sax, 1972). It can be very useful for remedial learning, since the computer is very patient. Student attention is more readily kept from distraction. The computer gives full attention to the student. And, the reinforcement technique is greatly appreciated by the learners who gain self-confidence working at their own pace without pressure like in a classroom setting. In the isolation of the study carrel, the students feel safe from possible frustrating reactions of the open class. Those students demonstrate a positive attitude towards CAI and they gain considerable performance (Margolin, 1970 and Sax, 1972). For adult education and life long learning, with its flexibility and availability at any convenient time for each learner, surely CAI is a very promising education medium.

Types of Learning

For what kind of learning is CAI most suitable? Relating Gagne's cognitive behavioral objectives (verbal infomation, intellectual skill and cognitive strategies) with the major types of CAI strategies, Kearsley (1977) comes to the following conclusions. Tutorial, which is an expository strategy, would be most appropriate for learning at the verbal information level (i.e., rote memorization and recall of facts), and at the intellectual skill level for discrimination (i.e., identification and recognition). Both can be reinforced by drill and practice. Tutorial can also present concepts involving categorization or classification, and rule learning and application, in an expository author control mode. The dialogue strategy is appropriate for rule learning in the case of inquisitory mode. In the latter, examples are presented and the student is expected to induce the rule. For higher order rules and cognitive strategies, dialogue is most appropriate.

As far as the subject matter (or content) is concerned, it is expected that CAI is the most effective use for social and natural sciences because of the large verbal information and concept learning skills involved in these subject matters. Nevertheless, actual CAI is predominant in mathematics. After all, it is rather recently that social sciences and language training have discovered its potential. The impact of CAI is particularly increasing in the health sciences. For example, in 1976, the number of CAI courses had more than doubled since 1973 (Kearsley, 1976). Tutorial is more and more used in introductory courses at undergraduate level. Drill and practice are best known for their usage in the training of basic skills (arithmetic and reading) in the grade school although their use is expanding in the training in foreign languages at high school and college level. Hence, we can appreciate all three modes of CAI for the different types of learning across disciplines.

Major Applications of CAI

In the experimentation and demonstration of the feasibility of CAI, some universities and computer centers have played an active role. Two forerunners who deserve special attention are: Stanford University and Florida State University. Two other systems are notably active in demonstrating high quality CAI at low cost, they are the TICCIT and PLATO systems.

Stanford CAI project. One of the first and most widely disseminated CAI systems started at Stanford University, Palo Alto, California in 1963. Under the direction of Richard Atkinson and Patrick Suppes, the Stanford project at the Institute for Mathematical Studies in Social Sciences received widespread reputations in the research and development of computer-based teaching and learning. Best known are the review drill and practice and tutorial in elementary math and reading. Elementary arithmetic by CAI is used in about 20 public school systems (Hunter, 1975). An outgrowth of the Research and Development program in CAI, the Computer Curriculum Corporation, founded by Atkinson is marketing the various Stanford CAI programs. Since 1969, the project is concentrating on basic research of a CAI learning theory, and the development of programs.

The initial reading program was conceived to help culturally disadvantaged children to acquire basic skills. It consisted of a supplemental curriculum given daily for 12 minutes at the terminal. A terminal station consists of an IBM terminal displaying microfilm images, a Philco CRT and a Westinghouse audio system with random access to prerecorded messages under computer command. The students may respond to the display by means of a light pen, the keyboard, or the microphone (Goodlad, 1966).

The arithmetic program, first conceived as an acceleration program for gifted first graders, is now covering a total elementary school math curriculum. It is based on a strand strategy. A strand is a content area within a curriculum consisting of related items whose difficulty level goes from easy to difficult. Within each strand, a grade placement by tenths of a year is foreseen. The computer keeps track of the student performance separately for every strand, evaluates, and adjusts the next assignment. A lesson at the terminal consists of a mixture of randomly selected exercises drawn from different strands on a basis of grade placement equivalency. A rapid gross adjustment for beginners is given to place them at a level challenging to their capacities. Other programs in the strand strategy are reading and language arts, grades 3 to 6. Other programs for high school level are logic, algebra, Russian (Macken, 1976 and Rockart, 1975).

Sponsoring of this very expensive project was provided at different stages by the Carnegie Foundation, the National Science Foundation and the U. S. Office of Education. The USOE funded the project from 1964 to 1967 for $920,000 and related work to the CAI project was supported from 1966 to 1968 for $9,444,000 (Hunter, 1975).

Florida State University CAI project. A second well-known CAI center is located at Florida State University, Tallahassee, Florida. It is directed by Duncan Hansen and sponsored by the Florida State Department of Education and USOE. This Research and Development center is concerned with theory, evaluation and implementation of CAI as a university instructional technique (Hickey, 1968). Although Florida State University (FSU) has produced a wide variety of courses as applied statistics, computer languages, social sciences, adult literacy programs, educational psychology, and others, it has attracted most attention through its introductory physics and chemistry courses.

Based on two computer systems, an IBM 1500 and 1400, the courses are organized in a multi-media approach. Besides the 1500 CAI system's CRT terminal with light pen sensibility, the courses require readings, audio lectures from a cartridge system, notetaking, concept film loops and projected films. The lesson sequence is made of different media according to the content. The whole system is directed by computer. Problems and instructions are displayed on the CRT, the student answers by typing on the keyboard or by pointing the light pen on the CRT screen.

After sign-on at the terminal, students are presented with a short quiz on the reading assignment received at the previous lesson. If they fail, they are instructed to re-read the text before taking another quiz. When they master the criteria, a short audio lecture is presented. During this lecture students have an outline at their disposal. A short quiz follows via CRT and audio. A single concept film accompanied by an outline is the following step. The student can also be directed to ask a proctor for a film projection on the topic. Another quiz is taken at the terminal on the film. The session continues with review problems and ends with a reading assignment to prepare for the next session. Mid-quarter and final examination review are available at a teletype connected with the IBM 1440. By this way the students get hard copy of the review for further study at home.

Cost-benefit analyses show that 95% of the money is spent in the development. Preparation of one hour of CAI is estimated at $2,420 for creation and $2,860 for revision which gives total cost of $5,280. This is a fair amount of money, especially when conclusions suggest that CAI, particularly simple tutorial, is rather limited in the support of learning in higher education (Rockhart, 1975). Perhaps it might be well to note that since 1972, FSU's CAI center did not produce new courses but concentrated on research in computer learning.

TICCIT system. A third example of intensive CAI activity is Timeshared, Interactive, Computer-Controlled Information Television (TICCIT) developed by Hazeltine Corporation, McLean, Virginia, in collaboration with the University of Texas and the Institute for Computer Uses in Education at Brigham Young University, Provo, Utah. TICCIT is a large five-year program funded by the National Science Foundation and directed by Kenneth Stetten. The basic goal of the whole project is to demonstrate that the development of high quality, completely individualized CAI is feasible at low cost (Rappaport, 1975).

The system, primarily composed of commercially available components, is supported by two interconnected mini computers (Data General Nova 800 series), one computer will serve up to 128 terminals and another to process student answers. The terminal, connected by cable with the computer, consists of a color TV set, headphones, and a special keyboard. The TV set has capability to display graphics and printed material generated by computer or video in a combination of different colors. Computer-controlled audio messages are received from a random access record player. A small integrated circuit memory, attached to each terminal, allows the conversion of the digital information from the computer to the TV display.

The course material is produced under the direction of Victor Bunderson. In a system's approach to design, teams of educational psychologists, subject matter specialists, media specialists and programmers collaborate in the design, development, and evaluation of the different modules. Major efforts have been concentrated on junior high freshmen English and mathematics. In 1974, the TICCIT system demonstration has been started in two community colleges. The summative evaluation of the project was conducted by the Educational Testing Service (ETS) in 1976.

The instructional modules are basically in a rule-example-application format with several levels of difficulty. Control of the learning session is greatly in the hands of the learner who makes choices by pushing the right keys at the terminal. Different options exist. They are initial overview, order of sequence, handling of auxiliary material, difficulty level, supplemental advice, and help. Cost for a system with 128 terminals is estimated about less than one dollar per student/hour in 1975. These cost-effectiveness results seem to demonstrate that CAI is a realistic device in education (Hammond, 1972, Rappaport, 1975 and Rockart, 1975).

PLATO system. A fourth very famous CAI system is PLATO (an acronym for Programmed Logic for Automatic Teaching Operations). It is a computer-based instructional delivery system currently under development since 1960, at the Computer-based Education Research Laboratory (CERL) of the University of Illinois, Urbana, Illinois. The PLATO system has been invented by Donald Bitzer. He is the Director of the CERL, where he leads a selected group of educators and scientists in the further research and development of the system. Today, PLATO is in its fourth generation. The purpose of the system is very similar to TICCIT. It provides high quality CAI at low cost. If a centralized system is used, the low cost can be obtained through a large base of student participation. Investigations are concerned with the different components of a highly centralized system, display technology, communication capabilities, processing and storage, software, and courseware development. PLATO is based on central computer facilities serving many users all around by means of remote on-line terminals in a time-sharing mode. In the case of Illinois, the large CDC CYBER 73 is located at the University of Illinois, Urbana-Champaign. It is estimated that there are thousands of terminals actually in operation, some on campus, others in nearby locations in Illinois and all over the United States. Florida State University started its PLATO system in 1975. Control Data Corporation, Minneapolis, Minnesota, has its own CDC PLATO system and is marketing its courseware to various industries.

PLATO users interact via a terminal consisting of a plasma-display screen to show visual information in an orange glowing manner, and a keyboard (the new terminals, IST I and II, are black and white). The plasma screen can display text at 180 characters per second by using a fixed-character set or character-sets defined by the course author (e.g., Chinese, Japanese, Greek). The terminal's memory contains 126 fixed characters. The terminal can draw lines, curves and circles permitting all kinds of graphic effects. Parts of the screen can be explicitly lighted or erased. It is also possible to erase the whole screen at once. A microfiche slide selector is incorporated in the terminal to proejct random accessible images on the plasma panel from the inside. This allows super-imposition of pictures and graphics. Further optional features of the terminal are a touch panel under computer control and auxiliary connectors for random-access audio device, possible multimedia devices, and external laboratory tools. Inter-terminal communication between users is another interesting feature of the system. The proper author language of PLATO is TUTOR, a simple but very powerful and efficient programming language that teachers can learn in a limited time of training. This language allows the creation of his own programming by the instructor (Paulson, 1976).

CERL Illinois is one of the most active producers of CAI programs in the U.S., in all kinds of subject matter from nursing to electrical engineering. The CAI lesson consists generally of textual material with associated visual displays and diagrams followed by question and answer. CERL has achieved part of its objective by providing a high-quality, interactive, self-paced instructional system; but it is still not within the reach of all schools.

Other CAI applications. Besides the four major centers and systems discussed above, several other universities are active in the development of CAI course material. (Hunter 1975). The University of California, Irvine, is known for its Physics Computer Development Program (PCDP). It is an example of CAI dialogue of two kinds. In an interactive proof dialogue the student receives instruction by questions and answers. The second kind is used as remedial instruction for unsuccessful answers in order to help the student comprehend what has been taught.

Ohio State University, in its medical school, developed a tutorial system optional for incoming students—Tutor Evaluation System. It controls understanding and delivers remedial tutoring if necessary.

Systems Development Corporation (SDC), Santa Monica, California, has developed computer assisted music instruction. Pennsylvania State University did something similar. The student plays the piano and receives visual display of the notes on a screen. The student wears earphones to hear instructions and music played by the computer or by himself or herself. Exercises in rhythm, harmony, melody and creative music are taught.

Pennsylvania State University is equally known for its mobile CAI program in special education CARE—Computer Assisted Remedial Education. The program is designed for undergraduates in education and in service teachers in rural areas. They are taught how to detect learning deficiencies and to decide what action should be taken. The computer is transported by means of a van to allow teachers in rural areas benefit from the program (Mitzel, 1974).

Effectiveness of CAI

Evaluation studies of CAI have taken place at the different CAI research and development centers. Their primary concerns have been with the technological feasibility of the various systems. Many comparisons between CAI and traditional instruction have been made in order to demonstrate the effectiveness of CAI. No simple clearcut conclusions can be drawn from these comparisons. Nevertheless, at the elementary school level, CAI appears to be effective as an addition to regular instruction (Edwards, 1975 and Visonhaler, 1972). There are indices that CAI drill and practice is more effective with students who start below the required level. It can best be used to improve performance, particularly for disadvantaged students. At high school and university level, results are inconclusive. A general conclusion is that the experimental groups scored as well as the control groups on achievement tests in comparisons between CAI and traditional instruction. Several experiments show considerable time saving with CAI (Vinsonhaler, 1972; Longo, 1973; Jamison, 1974; and Edwards, 1975).

Evaluation of student attitude pronounces itself in favor of CAI. Students like it. Their enthusiasm is because of interactive self-paced kind of instruction and the feedback after their answers. Students consider CAI as an effective instructional system (Smith and Sherwood, 1976) and enjoy working at the terminals.

In some cases CAI, especially PLATO Assisted Learning, shows to be the solution for the problem of shortage of qualified staff in certain disciplines such as French, Russian, Japanese, and other foreign languages. (Rockart, 1975).

As a whole, evaluation is considered very difficult as long as there is not "a widely accepted evaluation procedure, even for conventional methods" (Alpert and Bitzer, 1970, and Smith and Sherwood, 1976). A proposal for a valuable evaluation procedure is made by Burris and Skow (1976). For the evaluation of CAI programs they mention different dimensions to take into account:

1. Appropriateness and validity of the subject-matter content.

The evaluator asks questions about appropriateness, degree of accuracy and level of quality of the material. A needs analysis and a thorough review by subject matter specialists are required.

2. Quality of instructional design.

There is a need for clearly defined goals and objectives, performance criteria, message design, sequencing, and place of this course in the context of the whole instructional setting.

3. Ease and effectiveness in student use.

The evaluators are concerned with how students feel about interactive participation, self-pacing, feedback on performance, and meaningfulness of the task. This information can be collected on-line during the formative evaluation by means of questionnaires or Likert scales.

4. Efficiency and effectiveness of the system, language, and programming.

Formative and summative evaluation should be based on pre-test/post-test results in relation to the pre-defined performance criteria.

5. Costs and benefits.

What are the costs and the benefits of the system in comparison with alternative delivery systems or in combination?

One of the advantages of the CAI system is its collaboration in the evaluation of the instruction. By keeping track of the results of students performance history, and testing data for item-analysis, evaluation on both the course and the student can be made. Up-dating and revision of sequences of the course might be improved based on this information.

Considerations for the Implementation of CAI

A major obstacle in the implementation of CAI systems is cost-effectiveness. Large capital investment is required for the purchase or lease of the computer facilities. A sufficient number of terminals is required. For centralized systems, communication costs are considerable. Operational costs and participation in the authoring of courseware are other elements to consider.

Another barrier might be the "mental ware" (Searles, 1976) or the attitude of teachers and professors. Some teachers and professors are not ready for innovation and not willing to accept change in their role. As a matter of fact, when CAI becomes the dispenser of instruction, the teacher's role might feel reduced. With CAI, teachers have to adopt new roles as planner, manager, and counselor. New patterns of classroom organization are expected. It seems difficult for many teachers to abandon the traditional role because they have a tendency to teach in the way they were taught themselves (Fitzgibbon, 1970). Other teachers pretend that the use of CAI would have a dehumanizing effect on the learners. A good solution for this case would be to let the teachers take a course by CAI, to let them experience the system before using it in their own classes. Computer literacy programs in teacher education are efforts in this sense.

Lack of clear evidence of the superiority of CAI over alternative strategies, lack of sufficient number of well-known and high-quality programs, lack of uniformity in programming languages, lack of documentation on what is available and how to get it are other objections (Hunter, 1975).

In brief, there are several reasons which hinder the implementation of CAI. However, in considering the intangible value of CAI, it is worth to implement a computer based education system as soon as possible. This is because CAI provides benefits such as accomodation of different learning rates, different preferred methods of learning, different goals, different prerequisite knowledge and skills, and the computer will ensure the students' proficiency. In addition, one quality CAI lesson can serve many students at the same time so that quality of instruction and consistency can be maintained.

COMPUTERS AS ENRICHMENT OF INSTRUCTION

Besides using the computer for the training of computer people in computer sciences or as instructional delivery system in CAI, schools can also use it to enhance regular instruction. Computer-based problem solving, inquiry, simulation and games are such applications.

Problem Solving and Inquiry

In problem solving and inquiry the computer provides the students with the necessary means to explore problems and to find solutions. Problem solving tools are programming languages and analytical packages which allow the student to develop the algorithm (or firm decision rules) of his/her problem by programming it and take over the chore of calculations involved. Inquiry, on the other hand, is concerned with the information retrieval of data necessary to upholster other problems.

Problem solving has not been developed to be CAI programs. And it is rather recently that this learning adjunct has become more and more expanded (Kearsley, 1976).

Two programming languages widely used in problem solving are Basic and APL. Basic is a simple programming language a student can learn in about 15 hours. It allows manipulation of a wide range of problems at the terminal involving textual material and arithmetic processing. Basic was developed at Darmouth College, New Hampshire, and is actually the most used programming language in secondary education (Bukosky, 1976). APL, an acronym for A Programming Language, is a more sophisticated language and more appropriate for complex mathematical problems. APL was developed at IBM Corporation by Kenneth Iverson and seems more appropriate at the college level.

Analytical packages consist of the computational aid provided by the computer through data reduction and numerical programs. A well-known example in the social sciences is SPSS (Statistical Packages for the Social Sciences) used in several universities. MATHLAB, developed at Massachussets' Institute of Technology (MIT) and the Culler-Fried system, developed at the University of California, Santa Barbara, are problem solving programs in mathematics. Students work in a self-discovery way on the solution of problems by trial and error. The advantage is that they do not need to spend the time and energy in complicated calculations required in the pre-computer age because the computer takes care of this.

Students have more opportunity to concentrate on the problem and its solution, while in earlier days most of the time was consumed in the computations. In the Culler-Fried System, the student works at a terminal with a special keyboard. Besides the usual buttons on the keyboard, special keys for mathematical operation such as SIN, SQRT, MAX and others are also available (Hunter, 1975).

A famous problem solving program in business sciences is Wilbur Pillsbury's Computer Augmented Accounting developed at Knox College, Galesburg, Illinois. Students solve their accounting problems with the computer. CompuGuide booklets provide them with the necessary instructions. The program is now used in over 240 colleges and universities (Hunter, 1975).

Inquiry is the computer support consisting of the availability of data bases related to different topics as social sciences, medical sciences, legal cases, and stock market investment data. Inquiry and problem solving go hand in hand as in the case of the IMPRESS project in Dartmouth. Students get access to a social science data base by means of a statistical package. Closely related are the general information retrieval systems like ERIC (Educational Resources Information Center) and the prospected National Science Information Network (NSIN) (Hunter, 1975 and Rockart, 1975).

Games and Simulations

While problem solving has been the major instructional application of computers, computer-based simulations and games are rapidly gaining ground as enrichment of instruction, too.

Concepts. Simulations are imitations or models of real world phenomena used to investigate some specific aspects. By manipulating the input variables or by making changes in the model, it is possible to learn more about the dynamic behavior of the system that is represented and about the interactions between its different components. Computer simulations can represent very complex systems with multiple variables and parameters and permit experiments under precisely controlled conditions. The words computer simulations and computer-based games are usually considered as synonyms although there is some difference. A simulation needs not necessarily be a game and vice versa. Computer-based games have an added competitive element as students play against others or challenge with the computer and get payoffs at the end by winning or losing (Shirts, 1976).

Purpose of simulations and games in instruction. In learning, simulations are used for several purposes (Glenn, 1977). In some cases, a simulation or a game is used as a springboard for instruction because of its motivating character. Students will experience the real life situation, they are active participants, and get intuitively a feeling of what is going on. The regular class activity following the simulation is more reality bound; the students are better prepared and their attention is sharpened on the topic. It is clear that the simulation cannot be too complicated or too long in such cases, and of course, the major objective of the instruction is related to the subject matter.

More complex simulations are used as the core of instruction. Students will discover on their own the basic knowledge and acquire the skills related to the topic. Sometimes students are allowed to build their own models, but this assumes the students have the knowledge and acquire the skills related to the topic. Sometimes students are allowed to build their own models, but this assumes the students have the knowledge of programming language or a simulation language like SIMSCRIPT (Wyman, 1970). Usually the models are pre-programmed and the students work under the pre-programmed configurations.

On most occasions, a simulation game starts with a presentation of some information about the situation represented and the rules of the game. The different interacting variables are communicated, and the student is asked to make decisions about input. After processing, the computer delivers feedback of the consequences of these decisions by displaying a tabular or a graphic output. The student is asked to adjust the situation by new decision-making. In this way, the student discovers the complexity of the interactions between the different variables and the basic pattern. By continuous decision making in the simulation the student is trained in problem solving and prepared for analogous decision making in the real world. Decision making is usually concerned with value judgment. Therefore, students are trained to take position and to live with the consequences which are central in the process of learning to make decisions.

A third purpose of the use of simulations can be as application of previous learning. After regular instruction of the basic concepts, principles and rules of a certain topic, students are given the opportunity to manipulate them in a quasi-real situation. This can be considered as the theory put to test, or practice of knowledge. In summary, computer simulations might be used as springboard, core, or application of instruction.

Rationale for simulation. Simulations and games have shown to be particularly useful in certain circumstances, allowing certain experiences and experiments which otherwise would be impossible for several reasons (Braun, 1972). It might be because of the real life situation is not at all available or too complex, as in the case of the moonlanding or in some historical simulation. It might be that the equipment is too expensive or too delicate like a cyclotron, an autoclave or an accelerator laboratory. In other circumstances, real experiments would be too dangerous as for the risk of radiation, explosion and infection. For other experiences, it would take too long to collect the necessary observations as in the case of dynamics of demography, or the data sample would be tremendous and impossible to deliver on an individual basis as in biology. Other real experiments cannot take place because they are considered immoral like in human genetics or because they do not tolerate mistakes like in medicine. Furthermore, the amount of calculations involved in these experiments exceeds the human capability.

Even where real experiences are available, simulations are very appropriate as complement or supplement. An example is the preparation of the student by simulation before attacking the real case as in dissection in biology or case simulation in health science. Another advantage of simulations is their reproducibility (Rase, 1969). In point of fact, with simulations it is possible to duplicate situations where, because some events occur only once, in real life this is not always the case. Another important feature of simulations is that they are excellent opportunities to train students in accurate scientific thinking and experimenting. An experiment by simulation allows the student to manipulate variables, change parameters, and enjoy repetition where it is needed. Because the computer takes care of all calculations, the student can concentrate on the real heart of the experiment, the hypothesis and the demonstration. Simulations allow more to be done in less time and provide experiences otherwise not easily available.

Audiences. Although the majority of actual simulation programs is used at the college level, their use is expanding at lower levels. Bukoski (1976) mentions that in 1975, 16% of the current computer applications in secondary schools took place in games and simulations compared to 11% in 1970, which means a substantial increase. The bulk of these figures is probably going to the games. It is also worth to note that not all games are learning games; there are also informal games not at all related to any subject matter. Games are very appropriate for younger students because of the active involvement of the participants and their challenging and competitive character. They are very appropriate, especially when the display at the terminal is iconic and concrete (Kearsley, 1977). Nonetheless, most teachers seem to have problems to integrate them in the regular instruction.

Because of the serious and self-managing character of the learning, simulations without the gaming character are for more mature students. Moreover, the tabular and graphic displays in diagrams of the simulation results require certain capabilities of analysis and synthesis which younger learners do not have.

Types of learning. For what types of learning is simulation most suitable? As opposed to the expository CAI-tutorial, simulation is an inquisitory strategy. Consequently, it is less appropriate for verbal information and concept presentation but more for discrimination and discovery of rules and principles, and for problem solving. Simulation allows the student to apply those rules and principles through further manipulation of variables and parameters at the highest level of cognitive behavior–cognitive strategy. This corresponds to what was mentioned above as one of the advantages of simulation–its opportunities for training in scientific thinking. Games also favor non-cognitive learning. Because of the many opportunities of the evaluation and decision-making, they are likely to have great impact on the formation of attitudes.

Subject matters best matching with this learning strategy are those which are particularly appropriate for generative logics because they are algorithmic in nature (Kearsley, 1977). Subject matters which emphasize problem solving and cognitive strategies are physical sciences, chemistry, biology, mathematics and programming.

Some applications of simulations. It would be a hopeless task to try to deal with all the simulations and games used all over the U. S. Nevertheless, some projects and programs have attracted attention and have been disseminated. One very active project in development of simulation games has been Huntington Two at the Brooklyn Polytechnic Institute. The proejct started in 1970, as an outgrowth of th former Engineering Concepts Curriculum Project (ECCP) and is funded by the National Science Foundation. Under the direction of Ludwig Braun, a large group of high school teachers developed 30 comprehensive packages based on computer simulation. Formative evaluation during the development phase and a large scale summative evaluation in 100 high schools and 25 colleges was conducted in 1971-72. The evaluation by means of a student opinion inventory was concerned with the value of simulations, the ease of use and the interest. The packages are designed in a way to be user tailored. Developed in a modular way, they allow teachers to use them in a variety of contexts. Some packages can even be used in different subject matters. They are published by Digital Equipment Corporation (DEC). Each package contains a teacher guide, a student guide, a resource manual on the subject, and the program on paper tape in BASIC computer language for implementation on the local teletype (Hunter, 1975).

One of these packages widely distributed is POLUT. The topic is pollution and the program simulates the implanting of a manufacturing company near a body of water. The company will dump waste and pollution is inevitable. The problem is to find the implanting with the least pollution. Independent variables are the type of body of water, the water temperature, the kind of waste, the dumping rate, and the type of treatment of the waste. Dependent variables are oxygen and waste scales, and the impact on the fish. As output, the students have a choice between graphic, tabular or both displays of the results over a period of time (Anderson, 1976).

Another very popular simulation, developed at the Institute of Technology, University of Illinois, is FOX-RABBIT. It is the simulation of an island populated only by foxes and rabbits. Foxes feed on rabbits while rabbits feed on grass. Variables in the simulation are birth rate of both species, hunting or escaping success, and mortality. Students request input, make estimates, modify input and explore the effects of the different factors on the evolution of the population (Hunter, 1975).

Besides in life sciences and ecology, simulations and games are very popular in business education and management training. FINANSIM is an example of simulation of financial management problems. It deals with how to acquire capital and how to use it for investments. Marketing management as price determination and advertising are treated in MARKSIM. INTOP is designed for general management training and deals with international operations and problems of international markets and multinationals. The Executive Game is concerned with top level management in all functional areas of business, marketing, manufacturing, logistics and personnel. PROSIM is a production system simulator. It allows experience in the control of a total production system: inventory, production and sales (Hunter, 1975). MARKET is a business game for high school students, from Huntington Two. This game simulates two competitive companies producing the same product. Students make decisions about production level, advertising and unit price. The computer reports results in profit, market share, cash on hand, inventory, amount of sale and total assets.

Winner of the game is the company which achieves $12 million in assets while the loser is going bankrupt (Bagley, 1977). Most of these business games lend themselves to group participation. They are considered as an excellent preparation for the real life situation.

Health sciences is another area where simulations are playing an increasing role. As mentioned earlier, this is an area where mistakes are less readily permitted because of the consequences. Preparation by means of simulations and case studies is an attempt to minimize the risks later. A very sophisticated example is the program SIMONE at the University of Southern California. A life-like mannequin is lying on an operation table and serves for practicum in anesthesiology. Injections can be given and the patient is able to breathe. Blood pressure is monitored and consequences of the administration are immediately fed back by the computer. CASE at the University of Illinois is a simulation program containing different cases where doctor and patient meet. Students are presented with a medical case and make a diagnosis followed by the necessary treatment prescriptions. At the end they receive feedback of the consequences of their intervention. At Massachusetts' General Hospital, students also have at their disposal a series of simulations of clinical cases and biochemical models. One program is deisnged for training in accurate organ identification (Hunter, 1975). The University of Minnesota has a program called Emergency to prepare medical students for quick and accurate diagnosis and treatment in emergencies (Anderson, 1976a). The procedure is very similar to the CASE program.

In physical sciences, chemistry and biological sciences, simulations are usually accompanied by randomly accessible slide projections. By this means it is possible for the student to manipulate the variables and the equipment in a surrogate manner. During the experiment, on request or as reaction to the student response, the appropriate slide is projected showing the right or wrong consequence of the manipulation (Wing, 1968a). Sometimes very complex and expensive phenomena are simulated. MacAlester College, St. Paul, Minnesota, uses a simulation of an accelerator laboratory in its physics classes. The moonlanding simulation is familiar in aerospace engineering and so is the simulation of a rapidly moving spacecraft (Bowling Green State University, Ohio) (Hunter, 1975). In chemistry, simulations are used for all kinds of complicated analyses (Daubert, 1977; Bayless, 1976 and Anderson, 1976b).

An area where simulations are rather sparsily used is education. Two examples are DATACALL (Dartmouth College, New Hampshire) and EXPERSIM (University of Michigan). These programs are designed for the teaching of research design and data analysis in psychology. At the same time they provide an excellent practice in statistics (Hunter, 1975). This series of applications of simulations demonstrates the wide versatility of this instructional technique.

Effectiveness of simulations in instruction. There has been very little systematic research on the effectiveness of simulations in instruction. As for CAI, most developers seem more concerned with the technical side, the feasibility of creating computer-based simulations, than with learning effectiveness.

In a review of research on CAI, including simulation, Edwards (1975) mentions the results for 5 studies on simulations. Used as supplement to traditional instruction, one simulation in college level chemistry provided better results for the experimental group. When simulation was used as a substitute for traditional instruction, the results were ambiguous. Of the 5 studies, two were in favor of simulation, two provided equal results and one study on three simulation games in 6th grade economics gave mixed results. One study compared simulation with individual tutoring and the results showed equal effectiveness. Three studies took the time factor into account and found all three that simulation requires less time than other methods of instruction. Wing (1968b) who did the experiments with the 6th grade economics games found a gametime for two of the studies of only slightly more than half of the time required by the traditional instruction group. When retention of learning was measured, two studies found that students who learned by traditional methods retained more. As a whole, the results with simulations are very similar to those found with CAI.

A formal evaluation of achievement with the patient-simulator SIMONE at the University of Southern California found that students need less time and also less trials before mastery of the required proficiency in administering anesthesia (Hunter, 1975).

Besides these systematic evaluations, there seem to be a lot of good faith in simulations as effective support for instruction. Simulations are considered to better prepare for future jobs than most actual teaching strategies, especially lecturing, because they are more linked to the real world. Students are more motivated and actively involved. Proper decision making is an inherent part which emphasizes on learning teaching. In some cases simulations are highly cost effective. For example, EXPERSIM (University of Michigan) figures a cost estimation for its simulated laboratory in psychology of $7 per student/hour, while the real experiment could not take place for less than $14 (Willey, 1976).

Criticism on simulation is another kind of non-scientific evaluation. Simulations are oversimplifications and thus misrepresent reality. Shirts (1976) gives a good reply to this judgment. Simulations are not in the first place designed to represent reality but to teach. Simulations represent reality for a particular purpose and therefore exaggeration and oversimplification might be part of the message design. Nevertheless, the basic question of validity of simulations remains. Does the decision-making process in the simulation represent the decision-making situation in the real world? It seems generally accepted that compared to other teaching strategies, simulation is the best approximation of the real life situation. Simulations are designed not only as a training tool but also as a utility in predicting the uncertainties.

When students and teachers are asked for their reactions, they quote simulations and games as highly interesting and worthwhile experiences (Shirts, 1976).

Considerations for implementation. Before talking about application of simulations and games in the classroom, it is supposed that the teacher believes that simulations can be a valuable support for some kinds of instruction. In other words, open-mindedness for innovation is a prerequisite.

A careful preparation of the use of a game is absolutely indispensible. What is to be taught? What is to be learned? What is the major type of learning? Does the simulation facilitate the realization of these objectives in a way that can compete with other alternative strategies? Prior information should be collected about the simulation: Has it been field-tested? Is it well documented? A recommended procedure for the teacher is to first try it out or to seek advice from a current user. In fact there is a "paucity of offerings" of outstanding or adequate simulations as compared to the amount of other instructional material on the market (Shirts, 1976). So, one needs to separate the corn from the wheat.

Organization of the simulation will have to be considered such as: How to let the whole class participate simultaneously if there is only one terminal? Is there a closed circuit TV available for connection? In the application of simulations one should beware of their limitations. For instance, in laboratory situations they should never completely replace real life observation and experiment (Pollack, 1976). Simulations are only support of instruction. Other instructional material will be required for a lesson using a game, as enrichment or back up of the course. What place will the game take in the sequence of instruction and how long will it take (Glenn, 1977)? Is prior knowledge required? They should be used sparingly to avoid students being fed up with this strategy (Shirts, 1976). In some cases slight modifications of a program can make it more efficient. The teacher should think about computer literacy for himself. At the end of the simulation, there is a need for post-game discussion to interpret the experience. A replay is sometimes recommended.

As a last consideration, the teacher should not neglect the evaluation of the efficiency and effectiveness of the game in relation to the pre-defined objectives. How was the performance of the students? How did they react? How long did it take? Was it worth the effort and the money? This evaluation should be documented and eventually fed back to the game producer or publisher. Revisions of existing material of future development could greatly take benefit from such approach, and so would the concerned students and their teacher. Courses could be improved. Student efficiency, learning effectiveness, and cost reduction will be at hand. In one word, instruction would become more productive (Willey, 1976).

COMPUTERS FOR MANAGEMENT OF INSTRUCTION

A last application of computers in instruction is designed for the organization and management of the instructional process. In their effort to individualize instruction and to adapt the learning process to the needs and capabilities of their students, teachers have a hard time keeping track of the individual progress and the performance of the class as a whole. Each student is working at a different task because of the individual differences in ability and pace of learning. Some students advance quickly while others fall behind and need remedial work. Test administration, correction and recording has become the major and almost burdensome task for the teacher. Computers are being used more and more in schools for administrative and instructional purposes. It is the advantages that the teacher can be freed from the clerical chore and be able to monitor the student learning progress. The computer-based management system, known as computer managed instruction (CMI), is designed in an attempt to meet these purposes.

Concept

Although CMI can be considered as a kind of instructional support, a distinction is made in this paper between the different kinds of support the computer can provide in instruction. CAI is defined as the kind of support where the computer becomes the delivery system and the substitute for the teacher in instruction. Techniques like problem solving and simulation are defined as enrichment or adjunct to the regular instruction. CMI, on the other hand, is not a teaching device; it does not deliver instruction. CMI is a management information system (MIS) that aids the teacher in the organization and planning of individualized instruction. It is an "integrated, man/machine system for providing information to support the operations, management, and decision-making functions" (Davis, 1974) in the classroom. It can be used with all types of instructional resources: the teacher, textbooks, and other media as disseminators of knowledge, including CAI.

Basic Model of CMI

CMI can be seen as a set of procedures and mechanisms for gathering and processing data concerning the learning process (student, curriculum, and resources) and returning useful information to the teacher for instructional decision-making.

Before CMI can be implemented, some requirements have to be satisfied. The subject matter has to be broken down into small learning units, modules or frames. As a result of the content/behavior analysis, instructional objectives are specified: general objectives per unit and more specific objectives per item within the unit. Performance criteria for mastery of the objectives are fixed and assessment procedures or criterion referenced tests are constructed. A student guide is composed referring objectives to the different learning resources available to achieve each module. At that moment, computer managed instruction can take place.

In spite of the fact that the different CMI applications have their own characteristics, a basic structure or manner in which the computer is employed can be detected (Baker, 1971). Four functions are generally assigned to it: test scoring and record keeping, diagnosis, prescription, and reporting.

If pencil and paper testing is used, after completion of the test, submit the mark-sensitive cards, the tests results are scored by the computer and records are stored on the student file. CMI keeps track of three kinds of scores: pre-test, progress, and post-test scroes. (In case testing is implemented through the computer terminal scores, are directed to the student data base.)

For diagnosis, the computer monitors student progress, it analyzes the scores by comparing them to the objectives or expectations and to the correspondent performance criteria, it checks mastery and detects difficulties and failures.

Based on the diagnostic evaluation of the test scores, corrective learning prescriptions are made for students with problems. These prescriptions are specific assignments to help the student to master the failed objectives. The most simple prescription is to direct the student to re-learn the failed topic with the same learning material. More sophisticated CMI systems guide the student through other learning resources to the desired objectives.

A last function of CMI is reporting. The computer delivers information resulting from the previous steps. Individual reports carry the student's name, score and possible prescription if the unit is not mastered. The failed objectives are coded and so are the corresponding remedial assignments. Group reports reveal the performance of the group on each learning objective and the remedial activities for children below criterion level. Summary reports accumulate the results over a long period in a performance data base.

Another approach to describe the computer-based management of instruction is defined in three levels by Resta, Strandberg, and Hirsh (1971). The computer provides the teacher support for decision-making on a descriptive, a prescriptive, and a control level.

Descriptive support is provided by reporting the student performance. The report reflects only test results and the teacher is free to use them in a way to make instructional decisions regarding pacing, grouping of students with same problems, and prescribe counseling or some other remedial measures.

Prescriptive support is obtained when the report, in addition to the information about performance, provides possible courses of action that might be taken. The teacher can make a choice among these alternatives.

Control support is given when the computer specifies instructional action to be taken with a specific student or a group of students. The monitoring mechanism is already programmed and the teacher's intervention is not required. This is the case with CAI where the management is incorporated in the system. In summary, CMI has four functions: scoring, diagonsis, prescription, and reporting of student performance. According to the computer programming, a more or less complex CMI service is provided.

Operational Structure

Among the uses of computer in instruction, CMI is probably the least expensive one. In many schools its implementation has occurred on the existing central computer facility in use for administrative purposes. Other CMI systems have been made possible through computer centers from nearby universities.

CMI is possible with mini, medium size, as well as large scale computers depending on the population of students to serve and the manner of use. Large computers have the advantage of larger capacity and are programmed by more sophisticated software while minicomputers, on the other hand, can be dedicated to the CMI activity with corresponding features and software. The latter are more reliable and in most cases, more cost-effective (Allessi, Anderson, and Biddle, 1976).

Access to the computer in CMI is possible by different ways. The earliest systems used an optical scanner to read the mark sense test sheets and to convert them into punched cards. The punched cards were usually batched in the evening, so that the reports were available for the teacher the next morning (Brudner, 1968). A very efficient system actually in use is an on-line remote typewriter terminal combined with a mark sensitive card reader. This permits immediate scoring after test completion. Coded print-outs inform the teacher (and the student) about the results and possible assignment prescriptions. Group and summary reporting is requested and answered by means of the teletype (Van Hees, 1976). Several CMI systems go even farther and allow the students to take their tests at the CRT-terminal. Feedback is given by visual display and the combination with a teletype provides hard copy if needed.

Input data is usually stored on separate files in the data base. There is a course file with the listing of the CMI courses. Test material and remedial assigments are recorded on separate files for each course and coded by objectives. Student progress is recorded on student files. They contain the student identification number, name, course code and unit code, number of tests taken, scores, and prescriptions in coded form. After each test, the student file is updated. Special software provides for the operation and maintenance of the different files. To operate CMI, three systems are available: the batch system, the remote job entry system, and the on-line interactive system. Input from the different components of the system (student, curriculum, and resource references) are stored on separate files in the computer memory. Output is delivered by means of hard copy or by visual display.

Overview of Some Current CMI Systems

Implementation and experimentation with CMI has taken place all over the U.S. and abroad. Most systems are sponsored by universities, research centers, and computer manufacturers to demonstrate the feasibility of CMI. Besides the common structure of use, they are distinguished by special features in the instructional design, in the operation, and in the facilities used. Some proejcts have become widely known and are taken as models for new implementations. A reivew of some systems in the U.S. will be completed by examples of CMI applications in Great Britain, Israel, and the Netherlands.

Project PLAN. PLAN (Program for Learning in Accordance with Needs) has been developed by John Flanagan in several schools (K through 12) in Iowa. The project is sponsored by the American Institute for Research (AIR) and the Westinghouse Learning Corporation. PLAN is based on Teaching Learning Units (TLUs) developed in accordance with the special aptitudes and learning characteristics of different students. Different TLUs are designed per learning obejctive in order to respond to various learning styles and using different media. The program permits the student to plan his own learning. A medium size central computer in Iowa City processes the daily test scores received by optical scanner and the reporting occurs via a teleprinter in each school office (Brudner, 1968).

Instructional Management System (IMS). IMS is a creation of Systems Development Corporation (SDC) and the Southwest Regional Laboratory (SWRL) in the Los Angeles City School District. Testing takes place once a week. The learning process is mostly conducted in groups. In a listening center in the classroom, students receive directions by headphone from an audiotape. The test sheets go by courier to SDC computer center and the results are batched in the evening. CMI reporting with prescriptions on individual and group performance permits the teacher to compose the most efficient groupings and to supply the suggested activities and alternative learning resources (Baker, 1971).

IPI/MIS. IPI/MIS (Individually Prescribed Instructional Management Information System) has been implemented in the Oakleaf Elementary School by the University of Pittsburgh's Learning and Resource Development Center. A manual IPI system existed before the computer component was added. Particular emphasis is given at the self-direction of the student during the learning activity. Mark sensitive test cards are read by an optical scanner and converted to punched cards at the terminal. In the central facility, the data is stored on a scratch file. Each evening, the student tape with the performance history is updated. The teacher can request information by means of a teletype terminal (Cooley and Glaser, 1969).

WIS/SIM. WIS/SIM (Wisconsin System of Instructional Management) is a product of the Research and Development Center for Cognitive Learning in Madison, Wisconsin, to support IGE (Individually Guided Education). The system is used in three elementary programs in schools in Wisconsin and Duluth, Minnesota: DMP (Development Math Processes), WDRSD (Wisconsin Design for Reading Skill Development), and SAPA II (Science, A Process Approach). The learning setting goes from individual to small group learning in a continuous non-graded program. The SIM monitors each child's development and prescribes instructional material appropriate for each failed objective. The computer provides different reports. One is the unit performance profile, which gives instructional grouping recommendations for those students who are working on the same objective. Summarily, multiple group recommendations are given for all different objectives and an omission report indicates the students who are alone working on a unit and who cannot be included in any group. Request of an individual performance profile for one child is also available (Dagnon and Spuck, 1977).

TIPS. Teaching Information Processing System (TIPS) is an application of CMI by Allen Kelley for an introductory course in economics at the University of Wisconsin. The traditional lectures and small group sessions conducted by teaching assistants (TA) are managed by TIPS. All over the semester, students take short multiple-choice control tests based on the course objectives. Answers are scanned and the results are transferred to the computer for scoring, diagnosis, and prescription. A few hours later, three types of reports are available. One report is generated for the student with the results and a possible prescription in paragraph form (not coded) of some remedial learning activity (e.g., homework, attendance of another lecture, supplemental reading, help from a TA). The teaching assistant report provides the TA with a group report, a brief description of the different assignments, and a list of the students recommended for special help. The professor's report contains a summary of student and TA reports. TIPS is a demonstration of CMI in a university course (Baker, 1971).

Other CMI Applications. The list of CMI applications becomes larger and longer. It would be too detailed to describe them all. A citation of a few more may suffice. Teacher's Automated Guide (TAG) in Portland, Oregon schools is known for its computer generated lesson plans. Project C-BE (Computer-Based Education) at the University of Texas has programs for computer-based construction, editing, and printing of multiple-choice tests (Bruell, 1976) and so has CTSS (Classroom Teacher Support System) in the Los Angeles City Unified School District. AIMS or Automated Instructional Management System has been developed by the New York Institute of Technology as part of GEMS (Generalized Educational Management System) (Finch, 1972). SPIMS (Student Performance Information Management System) is working in Salt Lake Valley School, Utah (Finch, 1972). A CMI system is used to support a competency based teacher education program in Vocational and Applied Arts Education at Wayne State University (Neuhauser, 1975). SIMS (Student Information Management System) is a shared management system for teacher education at Florida State and Florida International Universities (Bonar, 1974). CMS (Computer Managed Study) is a demonstration of CMI with small computers (Daykin, 1975). Another interesting experiment is now conducted by the U.S. Navy with CMI by satellite for on-the-job training (Polcyn, 1976).

In Great Britain, the Royal Liberty School or the London Borough of Havering Educational Computer Center has been working with program CAL (Computer Aided Learning) since 1970. Students receive computer aided learning tasks (CALTs) with a teaching and a testing section, both developed on the basis of Benjamin Bloom's taxomony of learning obejctives. CALTs are of three types:

main line CALTs on three levels of difficulty, remedial CALTs to be taken by students who failed, before going on to the next main CALT, and enrichment CALTs for fast learning students. As a matter of fact, the system is built on the individual pace of students. CALTs are tasks for a whole week. Computer processing of the tests provides work allocation and information for the coming week by means of a student output sheet, a summary allocation sheet, and an apparatus list. Student answer sheets are also printed by the terminal. A handbook with instructions guides the new teacher in the use of the system (Broderick, 1976).

Israël is actually experimenting a CMI system called EXER (from exerciser) in a high school in Beer Sheva. The project is directed by the Ben Gurion Unviersity of the Negev. The system is working on a time-shared minicomputer with two typewriter terminals. The instruction goes by five activities: a classroom presentation, an EXER session, remedial reading or teacher tutoring and homework preparation. The EXER session consists of checking the achieved homework, possible presentation of remedial reading or prescription to consult the teacher, and assignment of homework or next activity. Operating problems arose with Hebrew, a language written with special characters and written from right to left, for the terminal print-out. A solution was found in a transliterated Hebrew. The system is found to be very flexible as a homework generator, guiz vehicle and support for individualized instruction (Bergman and Varol, 1976).

The last example in the series of CMI systems is an experiment in the Netherlands, a joint proejct of the Educational Research Group and the Engineering Mechanics Group at the Einhoven Unviersity of Technology and the Educational Center at the Tilburg University. At the moment, the system is shared by six universities. The instruction is based on individually prescribed study formats. Students learn from textbooks with a study guide. Testing occurs on mark sensitive cards and is followed by immediate scoring by a proctor operated mark sensitive card reader connected with a teletype terminal. Tests are non-adaptive and composed of items randomly selected from a question bank. Reporting is in coded form, and only on the failed items. Advantages of the system are better student service and improved results by relatively small investments (Van Hees, 1976).

The Teacher's Role in CMI

The use of the computer in the management of instruction has brought great change in the teacher's role (Kooi, 1970). As the name CMI erroneously could suggest, it is not the computer that manages the instruction, it supports the teacher in doing so. Decisions are finally made by the human component of the man/machine system. The teacher's role as instructor has become less and less important and the manager's role is more and more emphasized. As a manager, the teacher is responsible for the planning, organizing, leading and controlling of the class (Davies, 1971). With the computer support, this can be done in a more efficient way. Management involves decision-making on a short- and long-term basis. Planning decisions are concerned with the establishment of learning goals and obejctives. Organizing includes decisions of choice among alternative learning resources in order to assure the most efficient and most effective one(s). Leading is concerned with the motivation, the encouragement and inspiration of the students so that they become really engaged in learning. Controlling consists of the comparison of the obtained results with the pre-defined objectives. Decision-making is invovled as to the possible need of revision of planning, efficiency of learning resoruces and leading strategy.

As the computer has taken over a large part of the clerical tasks and has given logistical support to the teacher in CMI, "additional" time is created for more interesting activities in the classroom. As managers of learning resources, teachers need to be media generalists in the use of different delivery systems to disseminate instruction. Time is now available for the deisgn and implementation of new course material. The human relations between teacher and students are now possible on a one-to-one basis for leading, counseling, guidance, and individual help. With CMI, it has become possible for the teacher to keep track of the individual progress of each student on a more realistic basis. Maybe the teacher will need some training and experience in the use of the computer generated reports before full exploitation. The teacher is enabled to group students with similar problems for a special session while others work on their own. New classroom patterns are inevitable. Another role facilitated by the CMI system is that of evaluator of the instructional system as a whole. Based upon the analysis of the group report especially, evaluation of the objectives, performance criteria, course material can be improved. Therefore, further research on different student learning variables is facilitated.

Considerations for Design and Implementation of CMI

The deisgn and implementation of a CMI system pose different problems and choices have to be made among alternative options. Instructional deisgn greatly determines the design of the CMI system. Van Hees (1976) reveals some important considerations to be taken into account: the design and development of the course material, the measurement techniques, and the operation characteristics.

For the course design, the following questions need an answer. What will be the course structure? Are the units sequenced in a fixed order or are they randomly accessible? Will the student have to start with the first unit or will he/she be allowed to start with a unit of choice? If a fixed course structure is chosen, units can be developed in a linear sequence or in an adaptive branched way.

Test construction is the next step in the design of CMI. The number of items per unit has to be fixed, uniform for all units or not. Is the test procedure adaptive to the different levels of difficulty? If not, is there a fixed set of items or a random selection of items from a question bank? How many attempts will be allowed to pass? Does the criterion level have to be the same for all students and for all units? What types of test items will be used, true-false, multiple-choice or combinations? How is the re-test conceived? Re-test of all the objectives of the unit or only of those where the student failed to achieve the criterion level? What kinds of feedback will be given, unit ro detailed obejctive feedback?

In order to operate a CMI system, the choice between large scale computer and minicomputer facilities can be considered. What mode of input is preferred, batch or on-line? Is access to the computer reserved for the teacher or will students also be admitted? Is the data accessible on-line or off-line? How will the data be stored, sequentially or randomly? What storage devices will be used? What kind of reporting or display is expected, full text or in coded form?

Another consideration of importance in the design and implementation of a CMI system is the teacher's cooperation. The consulting of this prospective user of the system has been shown very adequate. Teachers are the persons who reveal their need of computer support. On the other hand, in contact with the designer, they will gain some understanding of the role and use of the computer, and what it can and cannot do in instruction. This will make them more confident and more ready to take the benefits of the system. A training session in using CMI and the supply of concrete procedure instruction is advised.

Although CMI is probably the least expensive application of computers in instruction, cost still remains one of the major considerations in the implementaiton. In large centralized time-sharing systems and now with much cheaper minicomputers, CMI is becoming affordable for more and more school budgets. Together with well designed course material, using all kinds of resoruces, and with an enthusiastic teacher, CMI can render invaluable services to instruction.

CONCLUSIONS

Computer-Based Education in the current status is still the state of the art. Greater efforts have been devoted by industry and public institutions. The first observation presented in this paper is the growing impact of computers in schools. Computers in education are used for two main purposes: for administration and for instruction. There is a growing need of using computers for administrative purposes and also for instruction.

The second observation is the tendency of emphasis on the insutrctional use of computers. Four types of applications are discussed: instruction about computers, computers as means of instruction, computers for enrichment of instruction, and computers for management of instruction. Because instruction about computers is already implemented in every part of the world, it is dealt with superficially. More emphasis is given to the other three uses: the CAI, simulations and CMI.

The major obstacle for implementation of computers in instruction are related to the cost or lease of computer facilities. However, an encouraging situation is that because of the technological development in hardwares, the computer prices are going down. Thus, this problem is going to be solved in the nearest future. It is not clear what type of computer is most recommendable to the users: large, medium or minicomputer. It all depends on the need of the user's organization and the scope of the instructional program. Moreover, the number of students to use the computer will also determine the cost per student. Basically, the users have to compromise between their budget and their expectations, and also the return on investment rate.

Computer-Based Education in the past years, and possibly in the coming years, is still the state of the art. It is because of the following reasons. First, the use of computer hardware potentials to achieve educational goals that are still under development. Second, the sharing of instructional programs (courseware) from one system to another is still unknown. This is because of the disparity of programming languages used by different computer models. Third, to adapt computer software to various educational requirements is still under development. Hopefully, by using software, hardware changes can be reduced to minimal. Fourth, instructional design and development is the determinant of the quality of courseware. Right now, professional people in this area are scarce. Even though there is quite a large working force in the instructional design and development field, however, quality designers and developers are hard to find. Computer use in instruction is based on the premise of individualized instruction. That is to say, all computer applications attempts are tailored to adaptation of learners' needs, such as learning task analysis, multi-entry point instruction in order to avoid redundancy of instruction and the like. Computer facilitates student learning in letting students have self-pace and self-managed instruction.

Computers can be used at all levels of instruction from grade school to postgraduate, from clerical training to managerial training. In addition, learning appears to be particularly effective by using CAI for those students who need remedial instruction after unsuccessful learning and tests.

Another implementation factor that needs to be considered is the role of teachers and professors in schools. The computer can take over a lot of the teachers' routine burdens. With the help from the computer, the teachers can concentrate more on human relation aspects of education and management of instruction. And in the meantime, they can upgrade the instructional program in the computer whenever it is necessary.

Through the analysis of applications of computer in education in the U. S., guidelines and applications can surely be drawn for this country, such as the current foreign language education method is a little bit outdated as indicated by the education professions in this country. The computer is a good teacher in presenting quality foreign languages to numerous students. Once a quality program is developed by a competent language teacher and a team of instructional development experts, the program will stay in the computer for years. The program will save the country a lot of money by using the current teachers for more advanced training. And at the same time, it is for sure the beginners can receive solid and basic instruction from the computer. The Control Data Corporation in Minneapolis, Minnesota, U. S. A. is trying to accommodate its PLATO system to Asian languages such as Chinese, Japanese and Korean. The preliminary results are very encouraging. If the feasibility is assured, then the PLATO system not only can present subjects with alphabetical languages (such as Spanish and English), but also with strokes and characters. In the decade of knowledge and information explosion, to educate numerous students to be knowledgeable persons should also take other alternatives. Classroom instruction can be efficiently used for human interaction type of education and training. Computer-Based Education can be utilized as a medium of delivering information and to take care of some instructional responsibilities.

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