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APPLICATIONS OF COMPUTERS IN EDUCATION

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Florida State University

ABSTRACT

The purpose of this paper is to demonstrate that the computer can be cost-effective in educational systems. Discussed are two major areas in reference to the role of educational computers. The first area will be the direct instructional support of computers; the second will be the indirect instructional support of computers. Direct support refers to using the computer in an instructional environment. Indirect support refers to using the computer as an additional resource in noninstructional activities.

APPLICATIONS OF COMPUTERS IN EDUCATION

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The introduction of the computer into the instructional system has been effected on an experimental basis. Several factors have contributed to this slow integration of computers. The sophistication and costs give a good rationale for the limited use of computers for instructional purposes. The computer requires almost continuous operation to make it a cost-effective machine. The business community has been able to take advantage of such a situation by operating computer facilities 24 hours a day. In education this has not been the case. Education traditionally has been geared to a nine-month year, five-day week, six one-hour instructional periods per day. As a result, the computer in an educational setting is idle most of the time. The purpose of this paper is to demonstrate that the computer can be cost-effective in educational systems.

Discussed are two major areas in reference to the role of educational computers. The first area will be the direct instructional support of computers; the second will be the indirect instructional support of computers. Direct support refers to using the computer in an instructional environment. Indirect support refers to using the computer as an additional resource in noninstructional activities.

Direct Instructional Support

Computer support of instruction can be segmented into three current types of activities: (a) computer-managed instruction (CMI), (b) computer-assisted instruction (CAI), and (c) learning simulations. The rationale for presenting CMI initially is a growing awareness that this instructional use of computers offers the most cost-effective model as well as the best potential for incorporating the other two types, namely, CAI and learning simulations (Hagerty, 1970; Gallagher, 1970).

CMI Computer-managed instruction can be defined as an automated approach to individualized instruction that implements the functions of (a) diagnostic evaluation with learning prescriptions, (b) the limited use of CAI for drill and practice or conceptual development, (c) counseling of the student about adaptive learning strategies, (d) the development of a scheduling system for optimally matching students with learning resources, and (e) the development of an appropriate student instructional record system. While CAI encodes the learning materials within the computer system, CMI depends upon a rich resource of conventional printed and multimedia materials being available. CMI uses the capability of a computer to monitor the progress of a student through a program of instruction, testing at many points, and using CAI techniques for remedial purposes. The resulting performance data base allows constant creation of more appropriate versions of the instructional program.

A number of projects have utilized CMI in their operations, such as Flanagan's Project PLAN (1967), Coulson's work at Systems Development

Corporation (1968), and O'Dierno's work at the New York Institute of Technology (1968). In these projects, students were guided to their learning materials based on progress information supplied by the computer to their teachers. Student instruction and testing were all performed with conventional paper and pencil procedures, and the data were fed through optical scanners into the CMI system. In turn, reports were supplied to the instructor and/or student.

The significant feature of Florida State University's approach to CMI is that the majority of the diagnostic evaluations and learning prescriptions takes place within a computer terminal-oriented interaction between the student and the CMI system. This allows for the inclusion of CAI techniques when desired within the overall approach. Secondly, it has the virtue of insuring that the students are responsible for correcting errors in the information flow both coming in and going out. And lastly, it allows a more facilitated feedback when the student receives his next learning assignment immediately.

The individualization process under CMI is primarily based on an operational understanding of the diagnosis, evaluation, and learning materials prescription techniques offered via an interactive terminal. Using an interactive terminal, such multiple dependent measures as error rates, error patterns, and latencies, plus the methodological techniques of sequential testing (Tennyson, 1972), and learning optimization models (Groen & Atkinson, 1966) can be employed. These hopefully will lead to a better representation of the diagnostic evaluation and learning prescription process.

CAI techniques (that is, the encoding of actual learning materials to be presented to the student) can be used within the CMI approach to (a) provide an improved dialogue in regard to learning relationships especially concerning the interrelationships among the behavioral objectives utilized within the course, (b) provide a dialogue in regard to adaptive strategies to be employed by the student, and (c) provide for conceptual remediation.

In reference to instructional counseling, students can be given an opportunity to constantly interact in regard to an overview of a CMI course and to gain information regarding their own progress. Students can ask questions about learning problems, adjustment processes, and their concerns for future learning activities. Such questions are most important from the student's point of view (Hagerty, 1970).

The CMI system can be provided with a schedule which matches human resources and learning material resources in an optimal manner. And, the overall development of a student record system with a CMI course will provide feedback information to students, counselors, faculty, and research and development personnel who are attempting to develop and revise CMI curricular offerings.

In terms of cost-effectiveness, CMI courses can be developed with a minimal amount of expense when compared to total computer courses such as CAI. CMI programming involves test administration with appropriate evaluation for student assignment on off-line materials. The cost advantage is that a large number of students need only a few terminals, and storage on the computer is small when compared to total CAI type

courses. Minicomputers (single terminal-computer units) to the largest machines can be used at rates comparable to usual instructional costs, i.e., costs per student hour. These cost rates are based on high enrollment courses, and assume amortized development expenses (e.g., 5-10 years). In summary, CMI courses are now cost-effective alternatives to traditional instructional procedures.

CAI. Computer-assisted instruction (CAI) refers to the direct use of computers as a disseminator of knowledge to the learner. CAI involves the interaction of a student on-line with a computer terminal. In designing CAI materials the designer has the following type of alternatives: (a) selection of an appropriate media device for presentation of curriculum, (b) the control of the rate of presentation, (c) control of the sequence of elements within the curriculum, (d) concurrent recording of all learning behaviors, and (e) a decision mechanism that determines the rate and sequence by which curriculum elements are presented to the student. The use of CAI in an instructional setting is limited only by the capabilities of the hardware, and more importantly, the content area. In designing materials for CAI, the content should not be sacrificed to keep it on-line.

Recent advances in the hardware and software area make it possible to use computers more extensively for direct instruction than in the past. Two examples are the Plato and TICCIT systems. The Plato system, developed at the University of Illinois, uses a terminal that allows not only for CRT displays, but also audio and visual displays from a slide projector. This system, although still in the developmental stage, does allow for a

more flexible approach to the design of CAI. A second approach is designed for the interaction of the computer with television. This is the TICCIT System, which is being developed cooperatively by Brigham Young University and the Mitre Corporation. This system is designed to use the capability of the television screen and audio with a connected teletype, all controlled by a central computer. Such a system will allow for the future uses of the computer in the individual home by cable television. Both of these systems rely upon large numbers of learners to keep the costs at a reasonable level. The two systems are still in the developmental stage although the Plato system is probably nearer to actual usage.

Other possible uses of CAI are with minicomputers. These are now available on the market by a number of builders who put together small individual computers which do not require the large central processing unit that is required on the two previous examples. A major advantage of the minicomputer is the individual control. The minicomputers provide ease for developing in-house materials at a low cost. Also, the efficiency of the minimachine makes it possible for dedicated use, i.e., the only user is the person interacting with the terminal, whereas on a larger central system the many users complicate the utilization of the machine in terms of allocating time. This problem has been somewhat solved by the use of time-sharing systems, but 40% of the system is usually allocated to the time-sharing monitoring functions. Although both approaches have advantages and disadvantages, the potential user should consider the following: (a) initial hardware costs, (b) years of possible use, (c) software development costs, (d)

other possible users (e.g., in large systems, instructors have to compete with research data analyzers who usually have more money), (e) access to the system, and (f) the immediate on-line instructional hours, and what is planned for the future.

The first major contribution to CAI was the development of the IBM 1500 Instructional System, the system in operation at the Computer Applications Laboratory at Florida State University. This system was designed specifically for use of computers in on-line instruction. However, the costs and the availability of instructional programs prohibited the wide use of the system resulting in IBM discontinuing the development of CAI computers. Throughout the country there are users of this system and over a number of years, a large number of programs have been developed which now demonstrate cost-effectiveness of computer-supported instruction. Other computer systems are available. Most of these have been developed by individual centers or laboratories in which hardware as well as software modifications were made on the basic designs.

Given the limitations of the CAI system in terms of the type of content which can be presented and the type of terminals available, the CAI system is still years away from being implemented as a major alternative in instruction systems. The costs of operating the system on-line per student is high except when used by large numbers (in the hundreds). The costs of developing CAI programs is also high because of the extensive labor needed for design and programming. The evidence that it is an effective system is strong, but at the present time it does not offset the costs. The future trends for CAI are the development of terminals which allow

for a greater or larger variety of display capabilities, such as the Plato and the TICCIT systems. These two systems are still in the future, and the costs are still debatable.

Learning simulations. A third use of the direct support of instruction by computers is in the area of learning simulations. Simulations are attempts at artificially presenting a real life situation to provide students with an opportunity to learn and play the role of a significant participant. Simulations can be divided into a variety of activities depending on the learning objectives desired. The simulation process allows the instructor to present real world type activities in the learning process. At the same time, a simulation requires that students themselves vicariously participate in a process which could normally not be available. Thus, a learner could be asked to respond to a simulation of a certain process displayed on the terminal, and have this response evaluated as to its effectiveness or to its correctness.

There are advantages and disadvantages of learning simulations. The advantages are: the presentation of situations too dangerous for real life, the design of scarce or costly events, and the testing of complicated or unmanageable situations (e.g., the simulated landing on the moon for a physics class). Simulation activities have the advantage of taking real life situations, putting them in a simulated context, and allowing the student to react to those prior to participating in a direct activity. For example, before allowing a biology student to go through the process of dissecting an animal, this could first be simulated on the computer with the student going through the process of dissection by use of graphics. Thus, his approach and his activities could be evaluated prior to actually

dissecting an animal. Also, it would allow for the quality control of students participating in other real life situations. The disadvantage of the learning simulation activity is the limitation of the computer itself, i.e., presenting the artificial situation rather than the real. Thus, in an artificial representation there is always the question of how the student would react given the real situation.

Simulation took an added meaning and value with the advent of the computer. The development of the computer gave man a tool with which to compress or expand time and manipulate parameters and variables of tremendous complexity. Man can make as many changes in his simulation model as he wishes, either by doing it himself or by programming the computer to do it automatically. Instructional simulations are a valuable tool in education because they can make learning more real and relevant to the world in which the student lives. By manipulating a model of some portion of the real world, a student is allowed to make his own decisions regarding certain variables. His decisions could have some drastic effects if allowed to occur in the real world. The student learns by asking the question, "What would happen if...?"

In terms of cost, the simulation process could be enormously effective. The military-industrial complex has been using computer simulations since the early 1950's. Only recently has the educational establishment incorporated this level of instruction in the system, mainly as games for the advanced students. Given the savings available in simulations over real life participation, increased usage is only hampered by the sophistication of simulation logic and programming. The

solution to this problem is an active training in computer languages and programming by members of all disciplines.

Indirect Instructional Support

As stated in the introduction, to make computers cost-effective in education, additional uses of the computer need to be designed. Such diverse areas as counseling, testing, and information retrieval are representative of the possibilities available.

Counseling. The first consideration in designing a counseling system is to define the nature of the counseling process and the potential computer applications. Counseling is the process of determining a person's current and past behavioral activities, i.e., what he is doing now, and then predicting the future activities of that particular person. The testing involved in diagnosis could be on an individualized basis on a computer terminal. The student could get immediate feedback where appropriate. Time involved in diagnosis and in prescription is reduced by having the interactive process occurring simultaneously. Depending upon the sophistication of the programming, the feedback on a person's responses could give the counselor suggestive ways of dealing with the problem. The type of testing given to an individual could employ some of the uses of learning simulations. A counselor could administer instruments such that the student is not aware of the type of information being collected. A counseling system which incorporates instantaneous diagnosis and prescriptions would certainly reduce manpower costs, and improve the affective climate of the service. Given the standardization of most testing, the amortized development costs make this indirect use of computers in education immediately available.

Computerized testing. Another area that computers are used in instruction is testing. Some of the earliest applications of computers in education were in the area of testing. The easily quantifiable nature of test results made these early applications obvious and logical extensions of the data analysis routines. Though somewhat unsophisticated, many of the early applications are still in use. However, computer applications in testing have continued to grow both in scope and in complexity. Some of the traditional methods of testing have been transferred to CMI-CAI activities, for example, multiple-choice-type tests. This would be the same as taking a paper-pencil multiple-choice test, except that additional data can be collected, such as, time, error patterns, sequencing, etc. More sophisticated advances in testing allow for individualized testing in which the instructional strategies could be adapted to meet individual differences. For example, on a pretest each student's performance differs according to the variety in previous knowledge acquisitions. The student scoring low on a particular section of the pretest would be automatically directed to the corresponding section within the program. Advantages of the computer are that it would allow immediate feedback to the student on his entering behavior, and immediate response to the program remediation in which the student should be involved. The pretest measuring could interact with other pretask measures (e.g., aptitude scores, grades, personality traits) available on the individual student, thus a more specific evaluation could be made. Likewise, once the student begins the task, measures could be taken to modify his sequence through a particular course of material. This processing component is very valuable because it does allow for the evaluation of the individual student and for individual

diagnosis or prescription. The output available depends upon the objectives of the course, such as immediate feedback concerning the correctness of the answer.

The interactive capabilities of the computer give the student the opportunity to make additional choices in an instructional system. Many programs allow learner control over decisions within a particular segment or course offering. Feedback given on pretest or intermediary performance could help the student in making decisions about continuing activities in a course. Learner control is limited without this type of detailed feedback on individualized learning progress.

In the direct instructional support systems described earlier, testing is an integral part. However, testing can occur in noninstructional areas, and it is in these areas that computers have rarely been used. Computerized testing on nationwide examinations, such as the Graduate Record Examination, could give the students immediate feedback on scores, thus, the decision-making process by individuals could be speeded up. Other exams given by colleges and universities to entering students could be scored immediately, making use of the computer system in noninstructional times, e.g., evenings and weekends, and other nonschool times throughout the year. By prearrangement of appointment times, testing could be on-line, and would not exceed the current costs involved in most university testing services.

Information retrieval. A third important area of indirect instructional support is in information retrieval systems. This type of system allows for the storage of information or data in such a way that it can

be recalled in an efficient or optimal manner. Libraries have been making extensive use of this type of system use by classifying and identifying books and other information. The capabilities of the computer made it possible to locate information at a faster pace than manual systems, plus the computer could identify in more detail appropriate resources. Generally, the more hierarchically the information in a discipline can be divided, the more beneficial a retrieval scheme. A retrieval system which is characterized by a multitude of decision points and a multitude of entries would provide maximum access to potential users. From the complicated branching system of the Dewey-Decimal system to a linear listing of facts and specifications, the computer would be cost-effective.

The use of digital telephones and a centralized retrieval system (perhaps state-wide) would reduce even further the cost of obtaining stored information. It is envisioned that word or phrase descriptors could be used as storage and retrieval labels. Such a system should be especially attractive to the academic scientific community because of the importance and the problems associated with obtaining recent and relevant research.

In summary, the initial costs and time involved are excessive. The project would involve long-term costs, including a complex accounting system, but the end product seems to outweigh the costs. The costs are high, and will stay high, but when used in a total computer system, it can be supported by higher income projects.

Social Factors

The use of computers in education presents social problems, as well as operational and costs factors. For example, due to the information

explosion and the creation of large data banks, it is no longer practical nor necessary for teachers to emphasize the transmission of facts. This facet of education can be handled more efficiently by computers. But the introduction of technology into the educational system has developed affective problems. One of these is a fear that computers will have a dehumanizing effect on students and teachers, and that they may even replace the teacher all together. The use of computers in education does mean a change in the roles of the teacher. Technology will replace the teacher in certain aspects of disseminating information. The research data are clear, computers can present information that is effectively and efficiently learned, plus the flexibility of the system does allow for individualized instruction which is not available in the traditional classroom. With the introduction of technology, the role of the teacher becomes that of an instructional manager, i.e., rather than personally disseminating the subject matter, the teacher selects and monitors learning activities appropriate to the individual student. In addition, the teacher would participate in the original design of the system, acting as a content specialist, and then participating in the revision of the materials in terms of the impact on the learning process.

At the university level many of the undergraduate courses with large enrollments deal mainly in the presentation of factual information which is fairly stable. Thus, much of what is taught in the system could be individualized by using some form of computer-supported instruction. The teacher would then have more time to participate in the individual process of working with students. On the graduate level, the use of

computers for instruction would be limited because of the limited number of graduate students per class. This makes the process of putting materials on the computer very expensive, except in those areas where there is going to be an immediate high volume of students and at the same time a relatively slow change of content. Meeting those criteria, the computer could be used on the graduate level. How does this influence the individual instructor or professor? Again, the technology removes some mundane activities and allows the professor more time for his research activities, and individual work with the students. What about the impact of technology on the individual? The end-of-course attitudinal survey of the undergraduate students in an FSU biology course showed that this was the first time since they had been in college that they had participated in an individualized learning situation. They felt they were getting the feedback on their performance which they needed.

Computers can be a cost-effective tool in the learning process if sufficient applications are designed and implemented by educators. Two major areas, direct and indirect, were selected to demonstrate the variety of uses in education institutions. Presented first, in the direct support of instruction, was computer-managed instruction. CMI is a monitoring system that diagnoses the learner on-line and prescribes off-line instruction. CAI, as the second application discussed, is an on-line procedure which does both diagnosis and prescription, plus the presentation of content. Learning simulations, the third, were described as learning environments artificially designed to represent real world conditions. Direct support of instruction is cost-effective given high enrollment courses. Even with such courses available, additional uses of the computer are necessary to achieve

maximum operational costs. Other applications of the computer were discussed in relation to counseling, testing, and information retrieval.

There are certainly many uses of the computer in educational environments. Described were uses in the academic community of higher education, but computer technology could be cost-effective in other postsecondary institutions; for example, community colleges, vocational-technical schools, neighborhood computer centers, etc. As the number of users increases, the variety of applications becomes greater.

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