CAI CENTER

TECH MEMO

THE ROLE OF COMPUTERS IN EDUCATION DURING THE 70's

Duncan N. Hansen

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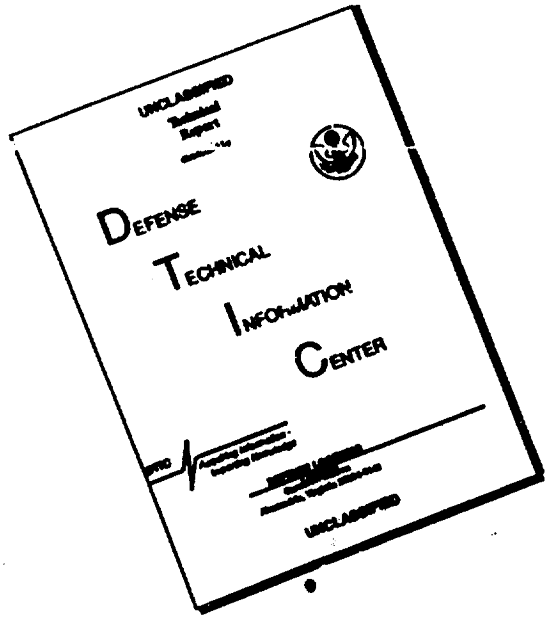

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The concept of an information management system is presented in order that the major educational functions can be conceptionally and operationally integrated within one computer center during the seventies. These major informational functions include: (1) information retrieval of administrative data, (2) scientific computing, and (3) computer supported instruction via computer-managed instruction, computer-assisted instruction, and learning simulation. The primary need for more sophisticated training of professional staff and support for personnel within educational institutions is discussed in great detail. The paper concludes with an economic analysis of some of the computer alternatives opened for support of instruction.

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The concept of an information management system is presented in order that the major educational functions can be conceptionally and operationally integrated within one computer center during the seventies. These major informational functions include: (1) information retrieval of administrative data, (2) scientific computing, and (3) computer-supported instruction via computer-managed instruction, computer-assisted instruction, and learning simulations. The primary need for more sophisticated training of professional staff and support for a personnel within educational institutions is discussed in great detail. The paper concludes with an economic analysis of some of the computer alternatives opened for support of instruction.

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The Role of Computers in Education During the 70's

The role of computers in educational management has a history comparable to that within the business world On the other hand, when one looks at the role of computer support of instruction, the development is still very much in its infancy (Bushnell and Allen, 1967). Given that one can identify the needs for administrative information handling, scientific computing, and the support of instruction via computers, it is little wonder that our current educational administrators find this particular part of technology both vexing and complex to the point of confusion

The purpose of this paper is to offer a simplistic conception by which most of the major educational functions can be conceptually and operationally integrated through the concept of an information management system. A second major thesis is that the primary needs of the educational world are not in the area of more sophisticated electronic equipment but rather in the totally underestimated requirement for training professional and support personnel within educational institutions to use even our existing computer technology.

Information Management System An integrated computer approach for an educational institution could be an information management system which includes the primary functions of (1) information retrieval of administrative data (conventional educational data processing is subsumed under this component), (2) scientific computing, and (3) computer support of instruction via computer-managed instruction (CMI), computer-assisted instruction (CAI), and learning simulations

Administrative Systems. In regard to the requirement for an administrative information retrieval system, it seems apparent that administrative data is only useful if it is retrieved in formats that provide a meaningful basis for decision making (Banghart, 1969). The subcomponents within such a system cover the areas of fiscal transactions, personnel, property and facilities, and libraries (Alcorn, 1966). It can be argued that within the coming decade all of the administrative information retrieval functions will be on a real time access, time-sharing basis with terminals located appropriately for each of the principal decision makers within the institution. Given the echelons within an educational institution, appropriate constraints can be placed as to the availability of data files according to the assigned administrative role The important point here is the advantage of near instantaneous reports to the crucial decision makers. This, of course, implies a significant training responsibility to allow these administrators to learn to use this information in a wise and judicious manner (Banghart, 1969)

Scientific Computing. As to the scientific computing component, this research requirement is growing at a fantastic rate. Most universities are finding that their scientific computing demands are fast outstripping their fiscal resources to provide such support to the faculty.

It is therefore conjectured that an appropriate regional network may have to be organized by which large computational problems can be handled. Obviously, the need for more sophisticated understanding of a scientific computing network would imply an even more enhanced faculty training and support program.

Computer Support of Instruction. The instructional component within the total information management system model can be further segmented into three current types of activities: (1) computer-managed instruction (CMI), (2) computer-assisted instruction (CAI), and (3) learning simulations. The rationale for presenting CMI initially is a growing awareness, at least at FSU, that this instructional use of computers offers the most cost effective model as well as the best potential for subsuming the other two types, namely, CAI and learning simulations (Hagerty, 1970; Gallagher, 1970).

CMI. Computer-managed instruction (CMI) can be defined as an automated approach to individualized instruction that implements the functions of (1) diagnostic evaluation with learning prescriptions, (2) the limited use of CAI for drill and practice or conceptual development, (3) counseling of the student as to adaptive learning strategies and appropriate career development, (4) the development of a scheduling system for optimally matching students with learning resources, and (5) 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 multi-media materials being available. CMI uses the capability of a computer to manage 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 are guided to their learning materials based on progress information supplied by the computer to their teachers. Student instruction and testing are all performed with conventional paper and pencil procedures, and the data are fed through optical scanners into the CMI system. In turn, reports are supplied to the instructor and/or student.

The significant feature of FSU'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 for a more facilitated feedback in that the student receives his next learning assignment immediately, as opposed to awaiting 24 hours or more.

Turning to a more specific review of these functions, the individualization process under CMI is primarily based on an operational understanding of the diagnosis, evaluation, and learning material 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 (Hansen, 1969) and learning optimization models (Groen and Atkinson, 1966) can be employed These hopefully will lead to a better representation of the diagnostic evaluation and learning prescription process

In turn, CAI techniques (that is, the encoding of actual learning materials to be presented to the student) can be utilized within the CMI approach to (1) provide an improved dialogue in regard to learning relationships especially concerning the interrelationships among the behavioral objectives utilized within the course. (2) provide a dialogue in regard to adaptive strategies to be employed by the student, and (3) provide for conceptual remediation.

In reference to the counseling function, 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 be allowed to ask questions about learning problems, adjustment processes, and their concerns in regard to their future careers. It has been our finding that these types of questions many times are the most important from the student's point of view (Hagerty, 1970). This CMI counseling activity also relieves much of the heavy demand on the human counselor within our educational system

In regard to the utilization of learning resources, the CMI system can be provided with a scheduler which matches human resources and learning material resources in an optimal manner. And, perhaps most importantly, the overall development of a student record system will provide for information feedback to students, counselors, faculty members, and research and development personnel who are attempting to perfect CMI curricular offerings.

Two studies (Hagerty, 1970; Gallagher, 1970) completed at FSU during the recent fall term report on a CMI development at the graduate level for a course entitled "Techniques of Systematic Instruction." The CMI approach involves student interaction directly at a CRT terminal interfaced into a computing system. The students did not receive instructional materials on the computing terminal, although the study directions and criterion tests seemed to have learning impacts in regard to the students' behavior. A two by two factorial design was utilized to investigate the sequencing of instruction and the evaluation of learning outcomes. The sequencing variable involved student control versus computer prescription while the evaluation variable involved human rating versus computer rating of actual course assignments. There was no significant difference between the means for the four experimental groups. On the final examination, all but one of the students achieved 80% on the final criterion test. It is important to note that such a high performance level is rarely achieved in graduate training, and represents, in our judgment, the potential of CMI as a more systematic individualized approach. (The cost-effectiveness relationships will be reviewed in a later portion of this paper.) We turn now to the nature of CAI.

CAI. CAI can be defined as a form of human-machine interaction whose goal is the efficient learning of the desired curriculum (Hansen, 1966; Ofiesh, 1968). In terms of the computing system, the pedagogical alternatives open to the CAI designer are as follows: (1) selection of an appropriate media device for presentation of curriculum, (2) control of the rate of presentation, (3) control of the sequence of elements within the curriculum, (4) concurrent recording of all learning behaviors, and most importantly, (5) a decision mechanism that determines the rate and sequence by which curriculum elements are presented to the student. This decision mechanism is commonly referred to as an instructional strategy although the consideration of the selection of media is also commonly included under this rubric. Optimization refers to the increase in efficiency found for one instructional strategy as opposed to another instructional strategy.

As an example of our CAI experimentation, we prepared a computer-based multi-media CAI physics course at FSU (Hansen, et al., 1969). This course yielded in the three replications approximately a 20% enhanced performance in comparison with a sample of students attending a conventional lecture course. Perhaps more indicative of the power of the CAI interaction presented via a CRT-light pen terminal, this CAI interaction was superior in comparison with the other media presentations such as audio-taped lectures, text reading, etc. In Table 1, the mean performance on CAI questions is presented along with the four other types of media. Table 2 presents the multiple regression coefficients found for each media type with the dependent measures being mid-term and final examinations. It can easily be seen that the CAI conceptual exercises had a greater impact in determining the final grade performance. This is not surprising in that the CAI-CR^T interaction was heavily stressed within the physics problem-solving aspects of the course Associated outcomes in regard to student attitudes clearly indicate that collegiate students prefer individualized approaches to their instruction and respond in a most positive manner when this is offered to them.

TABLE 1.--Mean Correct Proportions on First Responses to Different Media Presentation Types by Conceptual Topics for the CAI Physics Course

CONCEPTS	AUDIO	TEXTBOOK	FILMS	CAI CONCEPTUAL EXERCISES
Scientific Measure	.632	.698	.611	.586
Optics and Light	.670	.733	.675	.673
Force and Energy	.703	.706	.547	.666
Electricity	.675	.703	.476	.653
Modern Physics	.666	.703	.486	605

TABLE 2.--Multiple Correlations of Media Type Categories with Examination Outcomes for the Physics Course

	MID-TERM EXAMINATION	FINAL EXAMINATION
Audio	733	.798
Textbook	.605	.694
Films	.587	.445
CAI Conceptual Exercises	.870	.901

Learning Simulations. As educational institutions benefit from the more cost-effective approaches of CMI and CAI, it seems reasonable that additional instructional enrichment will be offered through the technique of learning simulations. Learning simulations involve the use of time compression and decision role techniques to provide students with an opportunity to learn and play the role of significant participants (Monroe and Beck, 1969). For example, it is quite possible to provide the role and decision-making aspects of an executive of a business firm that progresses through a 20-year time cycle within an instructional period of four hours A simulation of this type has been developed at the FSU-CAI Center (Hansen and Hannum, 1970); it provides for three parameterized conditions: (1) inflation, (2) depression, and (3) a normal business cycle. This sophisticated approach to teaching the nature of business management has been found to be highly enriching as a pre-professional instructional experience as well as being utilized as inservice experience for business administrators returning for short periods of time

We are also preparing a learning simulation which focuses on the cognitive decision-making found within statistical hypotheses testing (Thomas, Hansen, and Lippert, 1970). This simulation provides for successive presentations of data, their representation as summary statistics, their potential application within certain statistical hypotheses testing models, and the actual outcome probability values. This simulation is providing a realistic conception to the student of the relationship between the quantified numbers and their potential outcome when statistical testing models are applied. The area of learning simulation holds great promise for the future, and one can speculate that this may become the most dominant form of computer support of instruction.

Obviously, all of the activities in CMI, CAI and learning simulation require an extensive commitment to faculty and staff development. The creation of these learning materials should be under the control of the professor or classroom teacher and, consequently, requires a high degree of new learning on their parts. In addition, the use of computer technology requires a new approach to individualized instruction. A new sociology within the educational operation is in the process of being developed. It undoubtedly would develop with fewer "trials and tribulations" if we would seriously commit ourselves to a training program that builds competency for the critical personnel within the overall operation.

Cost for CAI and CMI. The costs for computer approaches to instruction can be broken into the categories of computer hardware, learning materials, and operational costs. The recent development of medium-sized, inexpensive computer systems, plus an anticipated drop in CRT terminal costs, makes the future look quite optimistic. We at FSU are presently working on a 64-terminal system for which we anticipate a hardware operational cost of approximately 20 cents per instructional hour.

In regard to the development of learning materials, the estimated costs seem to vary considerably, depending on the nature of the learning material as well as the expertise of the authoring group. Table 3 presents the actual cost of the development of the FSU Collegiate Physics course as well as the CMI course previously described As can be observed in Table 3, the cost differential between CAI and CMI is something approaching four orders of magnitude. Given this great cost differential favoring CMI, it would appear that this is obviously the pathway in which computer development will take place over the next three to five years. It should be noted that as less expensive computing equipment becomes available, CAI and CMI will have somewhat equivalent costs.

TABLE 3.--Cost Analysis for a Collegiate CAI Physics Course and CMI Course Curriculum Development Project

CATEGORY	CAI ITEM COST	CMI ITEM COST
Curriculum Preparation		
Behavioral Scientists	12K	0
Writers	12K	1 3K
Physicists	6K	
	30K	1 3K
CAI Coding		
CAI Coding Personnel	12K	4.3K
Computer Time	10K	3.5K
	22K	7.8K
Film and Graphics Production		
Art Work and Service Cost	.6K	.2K
	6K	.2K
Computer Programming		
Data Management Programming	54K	0
Data Analyses Programming	15K	0
	69K	0
CAI Instructional Cost		
CAI Computer Costs	15K	.9K
Proctors	3K	0
	18K	9K
Experimentation		
Graduate Students	24K	.8K
	24K	8K
Office and Clerical	10K	0
University Overhead	60K	0
TOTALS	239K	11K
Cost per Instructional Hour		
a. Development	$4.07	$1.04
b Operations	1.79	.59

Returning to the topic of faculty training, the experience in this area is still so limited as to make most cost estimates guesses, at best, into the future By the judicious use of undergraduate and graduate students plus interested faculty, a significant program can be mounted at any educational institution. Perhaps the most discouraging part of the faculty training issue is that commercial firms have almost totally ignored the requirement It is precisely in this area that the greatest commitment should be made if one wishes to accelerate the utilization of computers for educational purposes.

Summary. The future role of computers in education can be viewed as most promising. An educational information management system that allows for administrative, scientific, and instructional functions is becoming conceptually clearer The rate of development appears to be primarily dependent upon the kind and extent of faculty and personnel training. The '70's may very well be the computer decade for education.

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