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ABSTRACT

A minicomputer-based computer-assisted instructional (CAI) system was designed at the University of Texas Medical Branch in an attempt to lower both the excessive hardware costs and the inordinate amount of time required for the preparation of each hour of instructional material associated with traditional CAI systems. A prototype system with an author-oriented language was developed and used by medical students. The system's programs consisted of textual content and of logic instructions which allowed the machine to execute the instructor's educational strategies. The system was found capable of handling complex, educationally effective programs and was well liked by students. In addition, it was learned that faculty were both willing and able to write their own programs after a short period of instruction. (PB)

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DESIGN CONSIDERATIONS IN DEVELOPMENT OF MINICOMPUTER-BASED COMPUTER AIDED INSTRUCTIONAL HARDWARE SYSTEMS

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Abstract

Computer Aided Instruction (CAI) has proven to be an effective educational technique for Socratic, drill, problem solving, or patient management programs. However, both excessive hardware costs and inordinate time requirements for preparation of each hour of instructional material have contributed to its slow development as an everyday tool. In an attempt to minimize these difficulties, the design of a minicomputer-based CAI System, the development of a prototype system and the preparation of an author-oriented language were undertaken. This system has now been tested by medical students, interns and residents on problem solving, tutorial and patient management simulation programs.

The system has been well received by the student population, has proven educationally effective with those programs for which such data are available, and has very significantly reduced both program preparation time and hardware costs.

The performance requirements used in designing this system will be discussed, as will the design used to meet these requirements.

* * *

The educational value of Computer Aided Instruction (CAI) is adequately documented,[1,2] yet its use remains quite limited. There are unquestionably a number of factors that contribute to its poor acceptance as a day-to-day teaching tool. Of these the high hardware cost and inordinate amount of faculty time needed for program preparation appear to be the most important. In an attempt to retain the program flexability and interactive abilities of traditional CAI systems, while substantially reducing program preparation time and hardware costs, a prototype version of a minicomputer-based CAI system was constructed at the University of Texas Medical Branch and a CAI language developed for use with this system. This report describes the considerations we found to be necessary in design of a functional minicomputer-based CAI system.

Computer aided instruction can be a highly interactive and evaluative tool and its potential can only be realized when these assets are effectively utilized. There is little to warrant its use as a text book or lecture substitute. Its interactive abilities make it suitable for a number of educational needs that have previously required extensive one-to-one student to faculty interaction. The teaching of problem solving techniques or use of patient management simulations are not amenable to group teaching and consequently receive little or no emphasis despite the obvious need to improve decision making skills. The following are the first few frames from a CAI program used to help students develop the ability to handle renal clearance problems.

Computer: Suppose you ran renal clearance studies on a patient and obtained the following data.
Urine flow rate: 2cc/minute

	Glucose	Inulin	Osmolarity	PAH
Urine	400 mg%	0.6 mg/cc	765 mOs/kg	3.2 mg/cc
Plasma	200 mg%	0.01 mg/cc	293 mOs/kg	0.015mg/cc

Can you calculate his T_m for glucose?

Student: No

Computer: O.K., let's be sure you know what a T_m is. The T_m for glucose is the maximal rate at which glucose can be __________ by the tubular cells.

Student: Juggled

Computer: Sorry, that answer doesn't make any sense to me. Take another look at the statement and rephrase your answer.

The T_m for glucose is the maximal rate at which glucose can be ________ by the tubular cells.

Student: Reabsorbed

Computer: Good. We want to know the maximal rate of glucose reabsorption. There doesn't appear to be a direct way of doing this; however, this value should be the difference between the rate of glucose filtration and the rate of glucose excretion. Take another look at the data and calculate the glucose excretion rate.
Urine flow rate: 2cc/min

	Glucose	Inulin	Osmolarity	PAH
Urine	400 mg%	0.6 mg/cc	765 mOs/kg	3.2 mg/cc
Plasma	200 mg%	0.01 mg/cc	293 mOs/kg	0.015 mg/cc

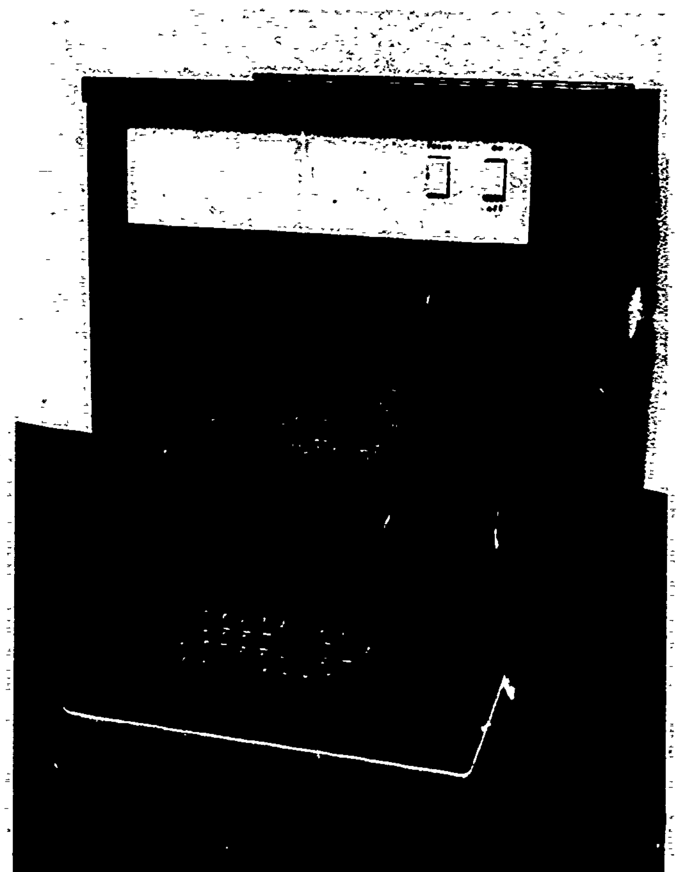
This individual's glucose excretion rate was __________?

Student: 8 mg/min

Computer: Right!
Now, what was . . .

Programs of this type consist of two parts: (1) the logic instructions that allow the machine to execute the educational strategies of the instructor according to his predetermined criteria and (2) the textual content of the program. The ability to store and execute the control logic for such a program requires little logic storage capability and its execution requires very little computer time. It is well within the capabilities of the currently available 12 or 16 bit general purpose minicomputers.

It is, of course, possible to store course content in computer core, on magnetic tape, or on a digital disc and read it out on a cathode ray tube or a hard-copy print-out device. Although this is traditional it may not be wise. When the computer is used in a conversational mode response time becomes more important than in some time-shared applications. Excessive delays between the end of a student input and the machine's response result in reduced teaching effectiveness. It is difficult to establish maximum allowable access times with any degree of accuracy, but, for use with medical students, "Worst Case" access



times of 4 to 6 seconds appear to be reasonable goals. Consequently, storage of course content on magnetic tape is impractical. Although it could be stored on a digital disc or perhaps even in core, utilization of computer time to process course content on its way to a cathode ray tube or teletype becomes increasingly impractical as the number of terminals increases. Through use of more independent storage and display devices it should be possible to service more terminals within any given access time allowance. A video disc, much like that used for television instant replay, in conjunction with an appropriate interface and television receivers can be used for storage and display of text, graphics or even photographs. Random access slide or film strip projectors, or microfiche projections with appropriate interfaces can also serve this function.

Upon receipt of a specific address by the interface, any one of these devices will access and display the frame of information designated. This is accomplished without use of the computer as routing path for stored information from the storage device to the display device, as is necessary, for instance, for CRT display of disc-stored text.

In medical education a requirement for large numbers of graphic displays (x-rays, photomicrographs, EKG traces, etc.) is often encountered. These storage devices are particularly useful when this requirement is present, not only because of the savings in processor time, but, more importantly, because they can all store and display graphics too complex for effective cathode ray tube display. Several of these devices afford adequate image quality to be used successfully for photomicrograph or x-ray display. This capability has proven very useful to us.

If one wishes to produce a system to take advantage of analog storage of course content a video disc/closed circuit TV system appears to be the system of choice. A basic two-disc pack can be equipped to service numerous terminals simultaneously through the addition of buffer tracks with fixed heads (one track per terminal) to the disc system. Video discs provide easy image recording and editing, rapid access, excellent image quality and reasonably large storage capacity. The cost of the storage and display devices necessary to implement this approach is competitive with that of hard copy terminals, cathode ray tube terminals, random access film projectors or microfiche projectors in systems of 15 or more terminals.

Most CAI systems use alpha-numeric keyboards for student input to the machine. There appears to be little reason to modify this approach. These devices are inexpensive, easily interfaced, and allow maximum flexability in the forms in which information input can occur. Although full paragraph natural language statements are desirable, this goal has not been achieved in a practical sense. One or two word answers, word lists, numerical answers with or without units, multiple choice answers, etc. can however be adequately handled by either traditional or minicomputer systems. These responses are evaluated on an absolute match basis. Consequently, the larger the answer, particularly when word strings are involved, the lower the probability of obtaining a perfect match. Although answers may be of any length, we have arbitrarily chosen to match only the first 50 characters of each response. This answer length limitation not only simplifies response identification, it makes practical the buffering of an entire response at the interface. This response may then be read into the computer, on demand, as a single entry. This procedure considerably facilitates time sharing on multiple terminal systems.

In order to demonstrate that hardware cost and program preparation time could be drastically reduced with an appropriately designed minicomputer CAI system using a flexible, user-oriented language, a single terminal prototype minicomputer CAI system was constructed at the University of Texas Medical Branch. Although the system was designed with video disc storage in mind, the prototype was limited to a single terminal using a Kodak RA 960 random access projector for storage of course content because of funding limitations. The terminal (fig. 1) consists of an alpha numeric keyboard and a screen on which course content is displayed by rear screen projection. The projector is controlled by the computer through an interface of local design.[3] An 8K Digital Equipment Corporation PDP/8E serves as the central processor, and an ASR 33 Teletype with paper tape reader is used for program preparation. This prototype system has been in operation since January 1972 and has been tested with Drill, Problem Solving and Patient Management Simulation programs.

We have found that reasonably complex, educationally effective programs can be readily handled by the system,[4] that it is well liked by the students and that through use of CAISO, a CAI language written for this system,[5] faculty can and will write their own programs after a brief period of instruction.

The economics of minicomputer-based CAI are also encouraging, especially when compared with traditional systems based on medium or large processors such as IBM's 360/40. A 10 terminal version of this system could be constructed for less than $40,000.

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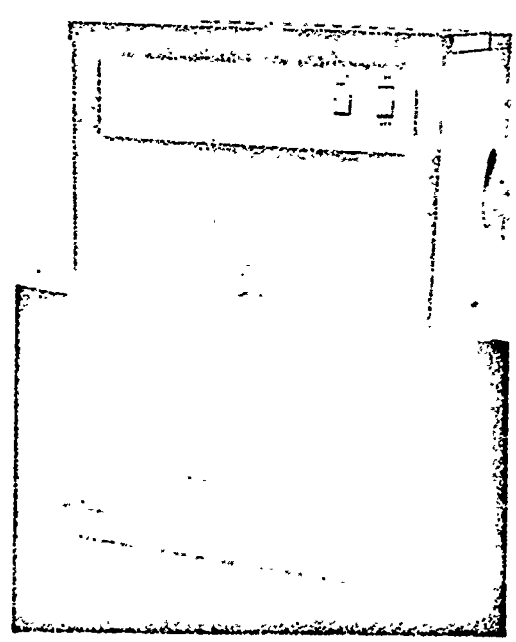

Figure 1

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