CAI Instructional Logic and Learner's Decision Strategies

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Abstract

The present study proposes to decompose the instructional situation into two decision components. One is the decision made by the instructor according to the choice of instructional courses and branching schemes, and the other is the decision by the learner which is made independently from the instructor's plan or intention. Thus any instructional system, especially a CAI system, must be equipped with both of these structures which reflect both the instructor's decision and the learner's decision.

We further propose that the real optimization of instructional system can only be accomplished by " balancing " the two decision-aspects, instead of pursuing more and more sophistications of only one of the two. From this point of view, we review various CAI systems developed in the past, and discuss our experience in the development of three CAI systems striving for better " balancing " of the two decision aspects in the system.

The results of a series of experiments indicate that the system is improved if it incorporates a facility for the learner to select his own course by self-evaluation together with diagnosis given to the learner by the instructional logic.

1. Introduction

It is obvious that any instructional situation involves two types of decisions; one is the instructor's decisions about what to teach or how to teach, and the other is the learner's decisions about what to learn and how to learn, or in a extreme case, even whether to learn. This is also true in Computer-aided Instruction (CAI). The machine "decides" what to teach and how to teach on the basis of a complex CAI logic, while the learner himself decides, more or less independently, about the pace of learning, the choice of alternative courses of learning and the way of responding, and so on.

Thus in the present study various CAI logics will be discussed in terms of (1) the number of factors taken into consideration explicitly in the machine's course selection and (2) the number of the learner's choice alternatives which are allowed in the system during the course of learning.

2. Dimension of Instructional Optimization

In order to make the discussion more explicit, let us propose here a two-dimensional space, the Instructional Optimization Space (IOS), in which the above two characteristics, (1) and (2), are taken as independent coordinates.

This paper first appeared in Japanese in Joho－Shori (Journal of the Information Processing Society of Japan), Vol. 15, No. 2 (1974), pp. 101～109.

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This research was supported in part by the Matsunaga Scientific Foundation.

Let us explain an extreme point A of the IOS chart shown in fig.1. Point A is assumed to be an "ideal" instructional situation in which the learner is almost completely free to choose any course of learning on any subject-matter, or responding in any ways. This means that the machine always adapts itself to such an infinite flexibility of the learner's responses.

Instructional schemes is well-balanced when they are located on the diagonal AO of this chart. That is, the machine's level of sophistication in the instructional logic must be properly balanced with flexibility of the learner's response mode allowed during the course of instruction. Therefore, it would not be advisable to simply increase the number of parameters in the decision structure of the machine, while accepting an extremely limiled number of the learner's options of learning strategies. Similarly, the learner's options of learning strategies should not be allowed unless the machine has the corresponding power to adapt itself to those options.

For the real instructional system, the data element of (1) is taken as the number of branching pattern Bp, and (2) as the number of the learner's options as shown in fig.2.

In what follows, some of the typical CAI logics will be evaluated by this space of Instructional Optimization. For this purpose, a number of CAI literatures are referred to as well as the technical reports for examining the detail structures on CAI's branching patterns and the learner's options.

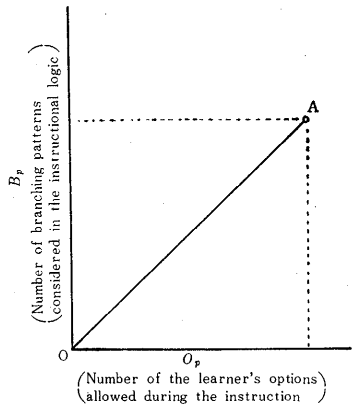

fig.1 The Instructional Optimization Space

2.1 Evaluations of CAI Logics Developed in the Past.

<u>SOCRATES SYSTEM.</u> The SOCRATES system by Stolurow and Davis (1965) incorporates quite a large number of different kinds of information to choose the appropriate instructional course for the individual learner. The system selects branching scheme on the basis of the learner's aptitude test scores, achievement level (e.g., IQ), the personality characteristics (e.g., test anxiety), the level of expected achievement, time limit, and so on. However, once the proper instructional program is chosen, the learner must only follow the given course, although the course may have some branching schemes. Thus the SOCRATES would be high in the level of the machine's considerations of various factors but the learner himself seems to have much less options.

<u>PLATO SYSTEM.</u> The PLATO system developed by Bitzer, et al. (1967) forms a marked contrast to the SOCRATES system in allowing a greater number of the learner's options in selecting learning strategies, while utilizing a less number of parameters in the machine's decision structure. In this system the learner can call upon "help" from supplementary sub-programs at any point of the instruction, as well as making "inquiries" at any time on some unknown information by using the computer storage as an information bank or a dictionary. The main sequence of instructional can also

branching off on the basis of the learner's error responses, speed of responding, and patterns of errors, and so on. However, in contrast to the SOCRATES, the PLATO system does not take into account the learner's personal scores on personality, IQ, achievement level, etc. Therefore, the system seems to be greatly oriented toward the stress on the learner's own decision during learning.

IMPACT SYSTEM. A better balance between the two coordinates of the IOS chart seems to be attained by the IMPACTsystem by Kopstein and Seidel (1969). Here, the main course of instruction is selected on the basis of the learner's aptitude test scores, educational level, and prior achievement of the previous programs, etc. Moreover, during the course of instruction, various branchings will be made on the basis of patterns of errors, total number of errors, reading time, response time, and opinions about the course. The most unique characteristic of this system is that it uses the learner's confidence estimates or subjective probabilities in order to select the best course of instruction. Therefore, this system is very high in both of the two coordinates of the IOS chart without losing the balance between the two.

The CAI logics as discussed above condensed into the following values of coordinates as (1) Bp=24,Op=2 in SOCRATES; (2) Bp=6,Op=19 in PLATO; (3) Bp=10,Op=9 in IMPACT; and are located on the IOS chart as shown in fig.2., respectively.

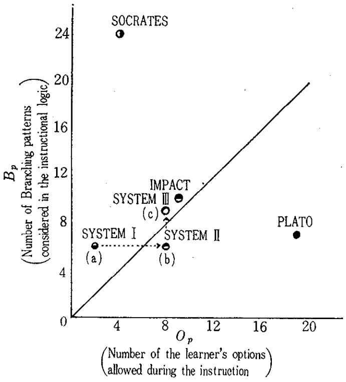

fig.2 Evaluation of Instructional Logics due to the IOS Chart

2.2 IOS Chart as aHeuristic Device

One of the main objectives for introducing IOS chart is to propose the use of this chart as a heuristic device to find the general direction of modifying and revising CAI systems. Suppose, for example, that an instructional system was located at (a) in fig.2., then it would be advisable to modify the system to incorporate more flexibility of the learner's own decision structure. We further suppose that the first revision of such a system incorporated too much of the learner's own decisions, thus point(a) shifts to a point(b). Then the next step is to add only a small number of parameters in the decision structure of the machine so that the learner's own decisions can be controlled to a limited extent. By doing so this second revision might put the system right on the balance line of the chart.

In fact, this is exactly the process we have attempted to follow in our revisions and development of our systems, i.e., System I, II, and III, which will be discussed next.

3. Experiments

The concept of the "optimal balance" between the machine's decisions and the learner's decisions in the instructional system is further explored by a series of experiments using three types of CAI systems, Systems I, II, and III. System I is an ordinary CAI system in which the machine determines the future course of instruction on the basis of the learner's past record of error reponses, while the learner has no intentional control over the choice of instructional courses. Since System I seems to be "unbalanced", weighting too much on the machine's control, System II is proposed in which the learner can have options at each instructional frame to choose from (1) rendering himself to the logic of System I, (2) seeing the correct answer without overt response, and (3) proceeding to the next frame without overt response or "feedback" whatsoever. Although most subjects instructed by System II seem to be quite capable of handling such options, it is observed that some subjects never adopt options (2) and (3) even though they are undoubtedly proficient. Thus in Sysem III the learner's decisions are diagnosed and the machine renders assistance when the learner has failed to take the proper options during the instruction.

3.1 Method

Subjects. -- Fifteen sophomore and senior students in the Department of Industrial Administration of Tokyo University of Science participated in these series of experiments.

Material and Apparatus. -- A programmed material, which dealt with basic notions used in analog computers, consists of fifty-two frames along a main linear sequence with several remedial sequences to branch off in case subjects make more than a certain number of errors at some particular frames. The entire set of frames are stored in the Personal Trainer. The subjects' answers are typed through a console typewriter of IBM 1130, which in turn types out correct answers and a number of other instructions, such as which frame is to be selected next. The systems are now implemented in the Dentsu TSS Mark I and II.

3.2 Procedure

Three types of CAI logic are used. In System I several patterns of branching schemes have been prepared and assigned beforehand by the programmer to various points of the main instructional sequence. During the instruction, each subject is forced to respond at each frame. If he answers correctly, he is reinforced by "OK" and allowed to proceed to the next frame. If he makes an error, then, according to repeat the same frame over until he answers correctly, or to branch off to a remedial program in case the number of errors at the frame exceeds a certain limit. In some frames, however, he is shown the correct answers instead of branching off.

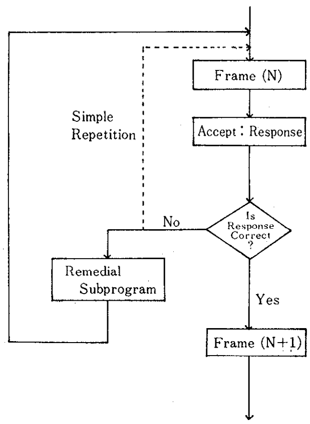

fig. 3 Flow Chart for System I. (Bp=5, Op=2)

In System II frames are categorized as either "regular frames" or "key frames". At each "regular frame" each subject has options to choose from (1): answering the frame followed by the same feedback procedure as in System I, (2): being typed out the correct answer with overtly responding, or (3): proceeding to the next frame unconditionally. At "key frame" each subject must always respond overtly. If he makes an error, his history of error responses and a record of the options he has adopted are typed out, thereupon he can either return to any of the previous frames or try answering once again and then return to any of the previous frames when he fails on the second try.

In System III, the machine is equipped with the same basic branching schemes as in System II. However, in System III the machine occasionally types out non-instructional messages which play the role of diagnosis when it is judged by the machine that the subject is overly cautious though he is in the state of sufficient understanding, thus prompting the student to adopt options (2) or (3).

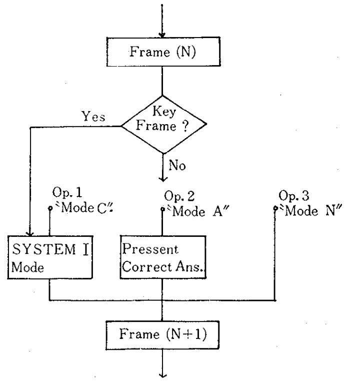

fig.4 Flow Chart for System II (Bp=5, Op=8)

In the series of experiments performed, subjects are divided into three groups, Group I, II, and III, respectively. The subjects are initially instructed from a taperecorder on the necessary information to respond on the console typewriter. At the end of the instruction by CAI system, each subject is given a post-test. (See fig. 3,4, and 5)

3.3 Result and Discussion

Table 1-(a) contains the medians and ranges of the time to complete the learning task under System I, II, and III; it clearly indicates that the subjects under Systems II and III learn much faster than those under System I. The average time difference between Groups I and II is 30.2 minutes and the difference between Groups I and III was 27.6 minutes.

Table 1-(b) contains the medians and range of the post-test scores (max.=10 points); there seem to be an increasing tendency in post-test scores from Group I to Group III.

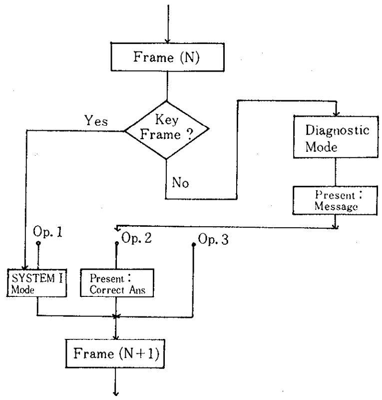

fig.5 Flow Chart for System III (Bp=9, Op=8)

Recall that under any system if a subject makes an error, he is forced to try the same frame again or branch off to some remedial frames; in either case the number of frames actually shown in the course will increase. The number of frames presented in the course of learning is shown in Table 1-(c).

Table 1: Time to Complete the Task, Post-Test Scores, Number of Frames to Complete the Entire Course, and the Number of Prompting Messages.

	(a) Time (min.)		(b) Post-Test (max.=10)		(c) No. of Frames to Complete the Task		(d) No. of prompts given during the Course	
	Med.	Range	Med.	Range	Med.	Range	Med.	Range
Group I:	73	65-123	5	4-10	53	40-55		
Group II:	50	34-63	7	5-7	38	32-46		
Group III:	52	36-70	8	7-9	35	33-36	1	0-8

(If a person makes no erroe throughout, he will be presented 25 frames as the minimum.) Table 1-(d) indicates the number of "diagnoses" prompting to adopt options (2) or (3) during the course of instruction.

The above results indicate that the subjects in Groups II and III do adopt options (2) and (3) by their own judgments and decisions, and that their decisions are generally correct. All subjects except one in Group III received less than 4 diagnoses during the course of instruction and one exceptional subject received 8 diagnoses, which is the maximum possible number of diagnoses.

(The latter subject seemed to enjoy receiving diagnoses regarding these as some kind of reward for not making errors. In fact he made no errors throughout although he took the longest time to comlete the task.)

4. Summary and Conclusion

The present study proposes to decompose the instructional situation into two decision components ; one is the decision made by the instructor according to the choice of instructional courses and branching schemes, and the other is the decision by the learner which is made rather independently from the instructor's plan or intention. Thus any instructional systems, especially CAI systems, must be equipped with both structures reflecting the instructor's decision and the learner's decision.

We further propose that the real optimization of instructionalsystem must be accomplished by "balancing" of the two decision-aspects, instead of pursueing more and more sophistications on only one of the two. From this point of view, we review various CAI systems developed in the past, and discuss our experience in developing three CAI systems which include better "balancing" of the two decision aspects in the system.

The results of a series of experiments indicate that the system will be improved if it incoporates in it the learner's own decision in course selection in the light of his evaluation upon himself together with diagnosis for the learner's decision by means of the instructional logic.

5. References

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