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ABSTRACT

Designed as the major component of a comprehensive model of educational management, a behavioral model of decision making is presented that approximates the synoptic model of neoclassical economic theory. The synoptic model defines all possible alternatives and provides a basis for choosing that alternative which maximizes expected utility. The more pragmatic or realistic behavioral model is based on a recursive programing paradigm, in which the decision maker has knowledge only of the state of the organization and its movement toward a selected goal. The two codeterminate aspects of this behavioral model are (1) the technology, plan, or curriculum; and (2) the management of that technology, the implementation of the plan, or the teacher's use of the curriculum. The model is illustrated by use of computer assisted instruction (CAI) and individually prescribed instruction (IPI). Program monitoring requires both a behavioral decision model and a conceptual framework, allowing the decision maker to distinguish between the plan and its implementation. This paper is related to document EA 002 902. (JK)

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PROGRAM MONITORING: PROBLEMS AND CASES

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Program Monitoring: Problems and Cases

In this essay, we discuss the necessity of a behavioral model of decision-making in educational management. We then present such a model. and show how it approximates the synoptic model of neoclassical economic theory. The behavioral model is incorporated into a comprehensive model of educational management, and we discuss illustrative cases where its relevance to a large-scale educational management monitoring project is apparent.

I.

Attempts abound in the gaming and social science literature to develop models which simulate the behavior of the administrator and decision-maker. Recently, these have been applied explicitly to educational management.[1] When one attempts empirically to validate these models, however, serious discrepancies occur. As Boguslaw and Davis put it, the model "behaves" more intelligently than the human it was designed to represent.[2] This presents the necessity for an explicitly behavioral as distinguished from the synoptic model of decision-making.

The behavioral model of decision-making emphasizes the pragmatic. Behavior, as characterized by this model, includes the following activities. The manager makes changes in order to improve only those situations which are patently undesirable. He addresses only those problems which are of manageable size. He makes changes incrementally, observes the consequences, both intended and unintended, and then takes corrective action.

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The synoptic model of decision-making was first developed by the economists of the Lausanne school. [3] Here the manager has complete information about both all the alternatives open to him, and the consequences of these alternatives. He then chooses that alternative which maximizes expected utility. [4]

The economist has traditionally concerned himself with the synoptic model. The economist sacrifices realism and practical relevance for analytic simplicity. As R. Day has emphasized, rational men don't behave according to models which smart men can't solve. [5] The synoptic model is insoluble, since it supposes information gathering and computational competencies of the decision-maker which are not finite.

The behaviorist or incrementalist has moved in the other direction, relaxing rigor and simplicity for realism. This sacrifice of rigor can take two forms: (a) one can propose to relax the synoptic model by introducing stochastic or satisficing elements, or (b) one can propose a plurality of criteria for the model, abandoning pure efficiency. While the second alternative seems the most popular, it is probably the wrong choice since insuperable weighting problems arise. [6] As Machlup has emphasized, we must not distinguish "economic values," cost-benefit ratios, efficiency, etc. from "human values." [7] We need to recognize that decision models are formal mechanisms for calculating, while the problem of determing what is the subject matter of their calculation is an empirical or policy issue, and not a formal problem of model construction.

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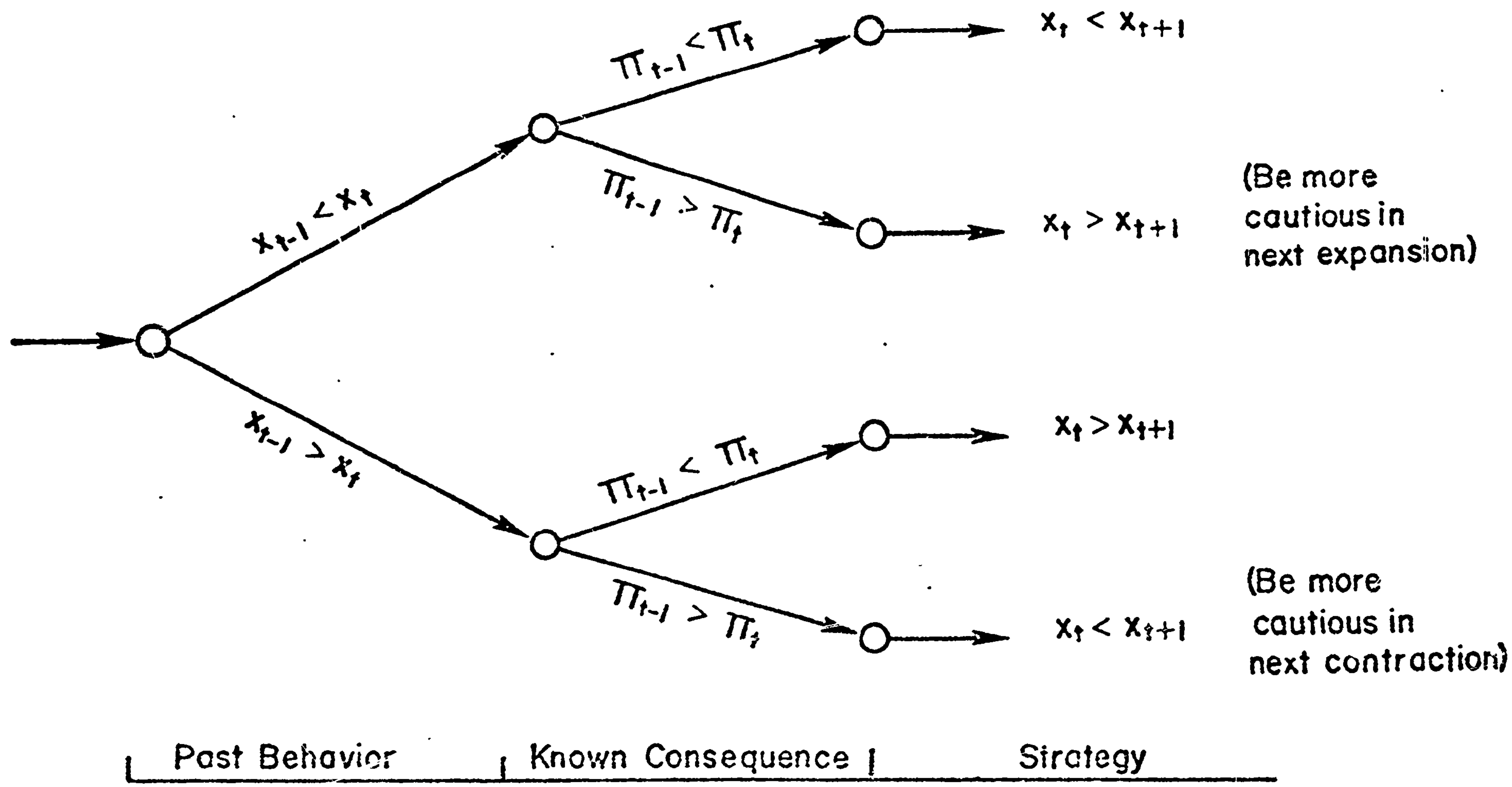
Hence, we will take the first alternative. Rather than excluding dimensions of value from our analysis on the grounds that they are "non-economic," we schematize how they can be introduced into the analysis. This requires that we construct a model which can at once accommodate the behavior of the real world decision-maker while retaining the analytic capacity for rational calculation.

We present a behavioral model of decision-making which is based on a recursive programming paradigm, and the premises of the behavioral school.[8] The decision-maker has knowledge only of the state of his organization and its movement toward its goal. Thus the model reflects both the impossibility of omniscience and the cost of acquiring information, both of which were ignored by the synoptic model. Indeed, the decision-maker knows no more than his last two decisions, x_t and x_{t-1}, where x describes the state of the organization in terms of output, and the results of these decisions on the criterion measure, Π_t and Π_{t-1}.

Since the decision-maker is otherwise in ignorance, he cannot try to maximize synoptically his attainment of Π. Rather than seek to maximize Π, the decision-maker must operate on two "learning principles": (a) he tries to repeat successful behavior and avoid unsuccessful behavior, and (b) he tries to use more restraint in behavior, if it is necessary to repeat an already unsuccessful behavior. The decision-maker's strategy is summarized in Figure 1.



$x_{t-1} < x_t$
$x_{t-1} > x_t$
$\pi_{t-1} < \pi_t$
$\pi_{t-1} > \pi_t$
$\pi_{t-1} < \pi_t$
$\pi_{t-1} > \pi_t$
$x_t < x_{t+1}$
$x_t > x_{t+1}$
(Be more cautious in next expansion)
$x_t > x_{t+1}$
$x_t < x_{t+1}$
(Be more cautious in next contraction)
Past Behavior
Known Consequence
Strategy

FIG. 1

Let x be the state-variable descriptive of the organization's activity level, and π be the criterion-measure. Since

$$\rho |x_t - x_{t-1}| = |\pi_t - \pi_{t-1}|$$

π is contractive for a suitable ρ. When $\rho < \varepsilon$ for the satisficing parameter ε, ρ is a contractive constant where $\varepsilon \to 0$. Thus

$$\lim_{\varepsilon \to 0} \frac{\Delta \pi}{\Delta X} = 0.$$

A plausible interpretation of π is "profit," and we can write

$$\pi = r(X) - C(X)$$

for revenue r and cost c of activity level x.[9] Then by the finite differentiation of π w. r. to x, we have at the limit the (discrete)equi-marginal condition $\Delta r/\Delta x = \Delta c/\Delta x$, which is the equilibrium of the profit-maximizing synoptic monopolist.

II.

As the French *philosophe* Montaigne put it, "Saying is one thing and doing is another." A behavioral consideration of an educational project has two codeterminate aspects; (a) the technology, plan or curriculum, and (b) the management of that technology, the implentation of the plan or the teacher's use of the curriculum. As we shall see, both aspects must be considered in a program monitoring effort. If we set our two aspects in a two by two table describing sources of variance in project operation, we have:

		Management	
Technology	Stochastic	Confounded Model	Technological Model
	Determinate	Management Model	Mechanical Model

If management is constant, we can test a particular technology. This is the upper right cell, and an example would be Computer Assisted Instruction (CAI). On the other hand, if technology is invariant, we can test various management modes. This is the lower left cell, and an example is Individually Prescribed Instruction (IPI).

Let us consider these two educational innovations. The distinction of technology and management makes apparent several critical aspects for monitoring programs. First, we will consider CAI. Some see the possibilities afforded by a comprehensive man-machine interface as a panacea to educational problems. In private industry, where viable educational and training innovations are eagerly sought after, the value of CAI has been long recognized: witness the IBM Corporation.

Indeed, for the management of a given curriculum, it is easy to see that CAI holds great promise. Competently programmed, a CAI program would monitor itself. But when we look to the other aspect of CAI, namely the curriculum, we have less cause for optimism. We lack a useful set of empirically validated principles of instruction that could form the foundations for a theory of teaching. Researchers have been unable to provide learning theories that can be put into instructional practice to take full advantage of the technology available.[10] This has an immediate implication for project monitoring: the curriculum must be refined. Two major areas in need of theoretical development for CAI are curriculum construction and knowledge of learning styles of youngsters.

<u>Content of the Curricular Lesson</u>

Let us look at the curriculum problem first. Various unflattering epithets have been applied to the CAI lesson. Critics have stated the CAI lesson is dull, boring material which can be represented efficiently; and, CAI technology is a replication of "the best of the worst of regular class-room teaching." What are some of the causes of curricular deficiency?

A multitude of questions emerge as one attempts to compile a CAI lesson. What is the optimum order to present elementary math? What mix of phonics and look-and-say methods is appropriate for beginning reading lessons? Does phonemic discrimination precede word production or phonemic production in foreign languages?[12] The magnitude of the problem for stimulus or curriculum sequencing is difficult to over-estimate. Problems of sequencing the curricular content are overshadowed by the problem of determing a student's pace and branching vis-a-vis that curricular lesson. Determination must be made on the basis of continual review of student performance. With the computer. selection from a set of frames is determined by any one or a combination of frame and student parameters. While educational technologists are aware of the problem, the important dimensions in such adaptive selection or generation are not well-known.

Another problem area in curriculum construction and presentation is the language problem. Most curriculum packages use languages which must be learned before the student can interact with the lesson. A natural interactive language, i. e., English, will take about ten years to develop.[13] Eventually, routines will have some of the characteristics of natural language processing: that is, in some limited sense the machine will understand a student answer or request.

Concomitant with the language development problems is the problem of language dependence and independence within the curricular less. Two kinds of prompting mitigate the learning potential of a lesson and introduce student search behavior variables. These two types are formal prompting and thematic prompting.[14] Formal prompting may involve either echoic or textual prompting where the stimulus is of the same form as the response to be evoked--rote memorization drills. Thematic prompting results from hints inherent in the entire interverbal dependency of language. The structure of language inescapably provides some prompts that determine a response.[15]

The types of responses the computer can interpret and respond to are limited. Mathematical problem solving may become highly complex and dependent upon computers, whereas a rich discussion of poetry has

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elements incongruent with computer support.[16] According to Suppes, one of the most difficult tasks is to know how to make use of unexpected responses in the way that a good teacher would. Also, unanticipated student errors and requestsaare important considerations in a sophisticated and semi-automated program monitoring system. Unfortunately, accommodations for these considerations are lacking in existing programs of instruction.[17]

Response Modes and Learning Variables

In this section we will discuss response modes and learning variables.

One problem with CAI technology has been the limited mode of response elicited from the student. Much of computer instruction to date has been restricted to typewriter or terminal input and output. Scanlon expressed, in 1969, the need for a terminal which can be used efficiently and effectively as an input device for learners. Response processing is an important aspect of most systems and often creates a problem.

Appropriate response modes and reinforcement schedules eventually hinge on the question of whether children have fundamentally different learning styles.[18] For example, are children either impulsive or reflective in the approach to problems? Do children reason inductively or deductively? Research has been done on cognitive styles but it has offered few solutions because it is primarily at an empirical level.[19] For instance, information about cognitive styles can be derived from past performance data. The amount of review work needed, time needed for the introduction of new concepts, etc., are influenced by the student's past performance. Unfortunately, scientific studies of how to use the facts about past performance are, as yet, in their infancy.

We have not presented this catalogue of problems in CAI, solely to sound like Cassandra. Instead, we think it necessary to recognize that while a computer can perhaps do well what we tell it to do, we must know what needs to be done. The problem is not implementation of a given curriculum, but the very existence of that curriculum. Only by clearly recognizing this can we expect the sort of payoffs from CAI that early enthusiasts have suggested were forthcoming.

III.

When we turn to the other case in point, Individually Prescribed Instruction (IPI), we find a different problem. In IPI, management or implementation is not controlled as it is for CAI. As we've noted above, two sources of variance may diminish program output. In the case of IPI, one source of variance, the technology or curriculum, is presumed to be completely controlled. The other source of variance, the management of the program, is continuously monitored by RBS.

A number of factors pose problems for the degrees of implementation in IPI. Weinberger has written that specifications for controls of the operation and models for monitoring and changing ongoing operations are lacking.[20] The IPI teacher is confronted with operational imperatives which he must administer according to his own judgment. Controlling and monitoring implementation is thus a crucial factor in IPI.

Complex problems such as the following are introduced when the teacher has on-site decisional autonomy. The teacher is under constant day-to-day pressure to produce results with learners with different learning styles, cognitive and affective characteristics, etc.; different teachers have varying cognitive and affective characteristics and different management capabilties; and finally, the existence of implementation problems is seen differently by different IPI locales - some see a problem where no problem exists and others do not see a problem where a problem does exist.

Because of the variations in implementation, "the task remains one of appraising and, if necessary, improving the degree to which" the goals and elements of the IPI Program "have been incorporated." To this end, RBS has developed a monitoring and information system. This system will perform three functions:

a. Assist school personnel in evaluating and improving their program by providing feedback on the system and how they can improve operations

b. Appraise training materials by determining if the goals and elements of IPI are upheld in field setting

c. Provide LRDC and RBS developmental information for refining and improving IPI.[22]

Three instruments are utilized as sources of information: the Degree of Implementation Study, the Report of Student Progress, and the Report of School Visitation Monitors. Degree of Implementation Studies are the main source of information. They determine how well teachers are meeting the operational critieria required in IPI's operational framework. These operational criteria fall into two major categories, first, the use of diagnostic instruments and second, the use of instructional materials and settings.

The use of diagnostic instruments and instructional materials is determined by collecting profiles (which reflect results of placement testing) and prescription sheets (which show the program of studies for each unit). In the 1968-1969 school year,"a total of 12,000 prescription sheets were evaluated containing 80,000 mastered skills." This number has grown every year.

Four diagnostic instruments are used in the IPI system: placement, pretests, posttests, and curriculum embedded tests. The required standards of performance for these diagnostic instruments are whether or not the test are given at the correct times and if the established mastery criterion is upheld. Questions pertaining to the diagnostic instruments were asked and the following results were obtained for the 1969-1970 school year.

Is the unit pretest given for each unit begun and are all skills tested? 98%

Are prescriptions written in accord with unit pretest results? 95%

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Are curriculum-embedded tests used properly? If a CET is failed, is there a follow-up? 94% If a CET is passed, is there a follow-up? 8%

. Are posttests used pooperly? Percentage of accurate follow-ups, 92%.

Instructional decisions constitute a second category of the operational framework of IPI. Differing learning needs of pupils require different learning materials and settings. Reports are available on the variety of materials and settings used. The frequency of use of a particular type of material and in a particular setting is calculated.

After the analysis of the use of diagnostic instruments and of the materials and settings prescribed is completed, results are sent to the IPI teachers. If the degree of implementation for a particular question was below 100%, an example of an error was printed out which included the pupil's number and the unit in which the mistake was found.

Two areas of evaluation remain: Student Profile Records and the Report of School Visitation Monitors. The Student Profile Record is compiled from a computer data bank file which contains IPI placement information for the number of students currently in the program. This file is updated in December and April to include placement information for new students and progress data for all students. After each update, teachers receive complete reports indicating a student's current placement and progress since his initial placement. Research and development groups can use this update information to determine if individualization of learning is being operationalized. For instance, the December update indicates whether students are mastering different numbers and kinds of skills, and the degree to which they do so. Research and development groups can use this information to trace the progress of all pupils throughout the nation through the IPI continuum.

The Report of School Visitation Monitors provides another source of IPI implementation data. Monitoring teams assist in effecting changes by: aiding in continuous training of the teachers and administrators; aiding personnel to adjust to the evolutionary changes in the school climate concomitant to IPI installation; and, providing theoretical and strategic assistance. The team's effort becomes imperative in terms of helping the schools use and interpret the large amount of information which is available. Thus for IPI, Research for Better Schools has established a nationwide program monitoring effort for program control.

In conclusion, we see that program monitoring, which is a variant of the modeling of educational management, requires both a behavioral decision model, as well as a conceptual framework which can enable the modeler to distinguish between the plan and its implementation.

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