DOCUMENT RESUME

ED 050 547 EM 008 907

AUTHOR	Clark, Michal C.; Merrill, M. David
TITLE	A Cybernetic Modification Scheme for an Instructional System.
INSTITUTION	Brigham Young Univ., Provo, Utah. Dept. of Communications.
REPORT NO	WP-6
PUB DATE	10 Mar 70
NOTE	20p.; Instructional Research and Development Series
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	*Conceptual Schemes, *Cybernetics, Feedback, *Individualized Instruction, Instructional Design, *Instructional Systems, Learning Characteristics, Systems Approach, Teaching Methods

ABSTRACT

One procedure that can be used to individualize instruction is to teach different pupils by different methods with the intent of reaching a common goal. A cybernetic (self correcting) procedure is proposed for manipulating instructional displays so that after a period of time the instructional procedure used is optimal for a given individual. This is accomplished by changing the parameter values of those parameters that define a given psychological condition or by changing the values and/or the parameters which define the content-specific conditions of a particular display. The instructional paradigm for each kind of behavior may have many parameters associated with it. A sample of these parameters may be modified, and if the learner response is correct, those modified values are returned to the system, and another set of parameters is selected for modification. If the learner response is incorrect, the same parameters are remodified in accordance with the rules. In this way, the model provides a method to maximize correct responses by the learner. It also monitors performance, and its dynamic property makes it always try to do better. (JY)

A Cybernetic Modification Scheme for an Instructional System

Michal C. Clark
M. David Merrill

ED050547

INSTRUCTIONAL RESEARCH AND DEVELOPMENT

A Cybernetic Modification Scheme for an Instructional System

Michal C. Clark
M. David Merrill

This is a prepublication draft designed for limited circulation. The reader's comments are solicited. Please do not cite as a source without consulting the department and the authors of this document.

Working Paper No. 6
March 10, 1970

Division of Communication Services
Brigham Young University
Provo, Utah

A CYBERNETIC MODIFICATION SCHEME FOR AN INSTRUCTIONAL SYSTEM

Michal C. Clark
University of Texas
Austin, Texas

M. David Merrill
Brigham Young Univ.
Provo, Utah

In his paper, "How Can Instruction Be Adapted to Individual Differences?", Cronbach (1967) suggested at least five procedures that are or can be used to individualize instruction. First, is to eliminate from further schooling those students which seem not to profit from the experience. Second, is to assume that certain learnings were necessary for every student and to have him continue to study a given topic until mastery. Third, is to modify the goals of instruction to match the needs of the individual so that different individuals learn different things. Fourth, to a fixed instructional program append remedial loops so that a student unable to grasp a particular skill from the main track is branched into a remedial sequence and then back into the main track. Fifth, is to teach different pupils by different methods with the intent of reaching a common goal. In some form all of these procedures are used in our present school system in an attempt to meet the needs of individual learners.

Cronbach indicated that psychologically the most interesting technique is the fifth, teaching different students by different methods.

This procedure poses some difficult questions. How does one decide which student should receive which method? How does one alter methods to meet the needs of individual students? What dimensions can be manipulated to alter instructional method? Which of these dimensions make a difference and which have little or no effect on instructional efficiency or effectiveness? This paper proposes a cybernetic (self correcting or self changing) procedure for manipulating instructional displays so that after a period of time the instructional procedure used is optimum for a given individual. The procedure described fits Cronbach's fifth category in that a fixed goal is assumed and instructional method is adjusted so that each student can attain the goal as efficiently and effectively as possible.

In the paper "Components of a Cybernetic Instructional System," Merrill (1968) identified three processing components. The selector consists of those rules for a particular kind of behavior (see Merrill, 1970) which state 1) the type of stimulus display needed, 2) the psychological conditions necessary to establish the behavior and 3) the most appropriate media to use to present the display to the student. The Comparator consists of those rules for a particular kind of behavior which state 1) the type of stiumuls display needed, 2) the psychological conditions necessary to adequately observe the behavior, and 3) the criterion of acceptable performance. The Program Modifier consists of those rules for a particular kind of behavior which indicate ways that the stimulus display can be modified under a stiuation where the student is unable to acquire the desired behavior from the initially selected displays. This paper suggests a procedure for implementing this third component.

This instructional model makes a number of assumptions. First, the psychological conditions necessary to establish or observe a particular kind of behavior do not vary with individuals. That is, a condition necessary for one individual is necessary for all individuals. A corallary of this assumption is that if a condition appropriate for a given kind of behavior is not present during the display the behavior acquired or observed will be different from that which was intended. Second, a given condition may be implemented with a number of different specific stimulus displays and these displays may differ on a number of dimensions. Individual students will respond differentially to different values on these stimulus dimensions.

Based on the above assumptions the following postulates seem warranted: If a modification procedure consists of changing the psychological conditions under which a particular kind of behavior is promoted or observed then the individualization which is taking place consists of a variation of the third type identified by Cronbach; that is, the goals are being modified rather than the instructional method. Program modification in which the instructional method is changed (Cronbach type 5 individualization) consists of maintaining the appropriate psychological conditions but modifying the dimensions of the stimulus display which do not change these basic conditions.

A given condition can be defined by a set of parameters[1] whose values[2] can vary thus specifying specific instances of the condition. A given stimulus display can be defined by two sets of parameters, one set are those which define the necessary psychological conditions for the type of behavior being taught and the other set are those which are content-specific, which define aspects of the stimulus display that are unique to the subject matter or particular display but which are not part of the necessary psychological conditions. Setting values for each of the parameters in these two sets defines a particular stimulus display.

Individualization by modification of instructional procedure (Cronbach type five) is accomplished by changing the parameter values of those parameters that define a given psychological condition or by changing the values and/or the parameters which define the content-specific conditions of a particular display. This paper discusses a scheme for systematically modifying parameter value to provide individualization by modification of instructional procedure.

Parameters for Classification Behavior: An Example

The application of the notion of parameter value modification to a particular kind of behavior for a concrete example may help clarify the above.

Merrill (1970) defined classification behavior as follows:

> . . . when a student is able to correctly identify the class membership of a previously unencountered object or event or a previously unencountered representation of some object or event.

The behavior specified is the student's ability to indicate class membership. This can be accomplished in a number of ways e.g. distinguishing a member from a nonmember, checking yes or no for a list of instances, sorting instances into piles representing different categories, matching category name with the instance. etc. Recognizing or reciting the definition or list of attributes for the class is not the appropriate behavior.

This definition suggests that a necessary condition to observe an instance of classification behavior is that unencountered instances and non instances of one or more concept classes must be presented to the student for identification. This condition is defined by the following parameters.

Parameter 1: Ratio of instances to non instances.

Some students may perform better when asked to pick out the single instance from a set containing several non instances while another student might perform better if asked to pick out the non instance from a set containing several instances.

Parameter 2: Number of simultaneous classes.

Classification behavior can deal with a single class having the student indicate members and all else as non members or it can deal with several classes at the same time having the student label each instance as a member of A, B, C or none. Students differ in the number of simultaneous classes they can handle at one time.

Parameter 3: Representation of referent.

Classification behavior is involved whether the student is asked to categorize actual events/objects or representations of events/objects. A scale from the referent (actual event/object) to simulation/model to picture (motion/still) to verbal description can be used to represent a given referent. Some students may do better with more literal representation while others respond best to abstract representation.

Parameter 4: Type of question asked.

Identification can be accomplished by using several types of questions (as indicated above). Some students probably respond better to one type while others prefer another.

Parameter 5: Discrimination required.

Instances of a given class can be very clear in that identification of relevant attributes is relatively easy while other instances may be much more difficult in that their attributes closely resemble members of other classes. Students differ in their ability to make fine discriminations of this type.

The above parameters do not necessarily represent a comprehensive list but they do enable us to specify the characteristics of a given display designed to assess classification behavior. Note that the conditions and parameters specified do not deal with promoting acquisition of classification behavior but rather with observation of the behavior. A similar set of conditions and parameters could be identified for behavior acquisition.

For illustrative purposes assume the concept to be taught is "Airfoil." The behavioral objective might be stated as follows:

Presented objects which are airfoils and those often confused with airfoils the student will be able to correctly indicate examples of airfoils. The statement of the objective has arbitrarily set the value of parameter 2 "the number of simultaneous classes" to a single class. Possible values for the remaining parameters are illustrated in Figure 1. In sample one a value is indicated for each parameter and the resulting display for the student is shown. Sample two illustrates the change in the question when two parameter values are changed.

Technical Modification Model

The proposed modification scheme allows the parameter values to be set differently for each individual in accordance with his own aptitudes. It also allows the parameter values to change as the individual's aptitudes (interests, acquired knowledge, etc.) change. Hence, the modification scheme provides a dynamic process for utilizing aptitude information.

FIGURE 1
CONCEPT AIRFOIL POTENTIAL PARAMETER VALUES

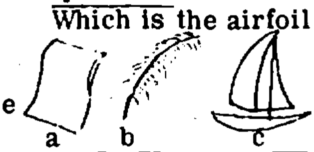
Type of Instance

Representation	Wing	Propeller	Sail	Space Capsule	Paper	Feather	Rocket	Boat
Actual Object								
Model								
Picture								
Verbal Description								
	Instances				Non Instances			
Discrimination	easy			hard	hard			easy

Sample One

Parameter	Value
Ratio	1:2
Simultaneous	One
Representation	Pictures
Question Type	Multiple choice
Discrimination	Hard

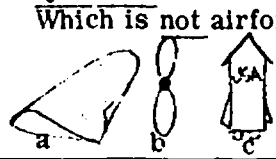
Question:
Which is the airfoil?



Sample Two

Parameter	Value
*Ratio	2:1
Simultaneous	One
Representation	Pictures
Question Type	Multiple choice
*Discrimination	Medium

Question:
Which is not airfoil?



*Values changed in sample two

The system requires that parameter values all be scaled from 0 to 1.0. Discrete variables fall into the same range with limens between values determined by mapping the corresponding aptitude scale into this restricted parameter scale. In other words, parameter values can be initialized in any way (e.g. randomly or at group means, etc.).

A parameter consisting of four categories might be mapped into a scale where category A was 0 - .25; B was .26 - .50, etc.

Once the system begins to operate, parameter values for a given individual are always changing. After every learner response, parameter values are reset. The operators used to change parameter values are given in Table 1. Operator A will result in the parameter value to be increased. Operator B will decrease the parameter value. After every response, one of the operators will be applied.

The selection of the operator to be applied is made independently for each parameter. The selection is according to a "win-stay; los -shift" strategy. Either operator may be applied after the first learner response. From then on, the selection of the operator is determined by the operator used previously <u>and</u> by the correctness of the previous response. After a correct response, the same operator is to be used as was used on the previous trial (win-stay). After an incorrect response, the operator that was not used on the previous trial is to be used (lose-shift).

This model provides a method to maximize correct responding by the learner. It monitors performance, and its dynamic property makes it always try to do better. A change in parameter values results in changes in the content. organization and sequencing of instructional displays. This model changes parameter values so that the values tend to oscillate around an "ideal valve" for the individual where correct responding is maximized. The band of oscillation is made narrower by decreasing the value of θ in the operators as a function of number of trials (as n gets larger, θ gets smaller).

If all of the parameter values were to be modified simultaneously, the changes could all be confounded and a few very salient parameters could mask inhibitory changes in other parameters. Thus, parameters must be modified at least somewhat independently of one another. Modifying one at a time provides independence, but optimization of instructional presentation would be incredibly slow. Thus, a sampling scheme must be used to allow a subset of parameters to be manipulated simultaneously. but to constantly change the members in the subset so that confounding of changes is effectively eliminated.

The instructional paradigm for each kind of behavior (Merrill, 1970) has many parameters associated with it. The sampling scheme then calls for a few (say 3) of these parameters to be sampled whenever an objective requiring that paradigm is being taught. The values of those three parameters are then modified in accordance with the above rules. If the learner response is correct, those modified three values are returned to the system, and another three parameters are selected for modification. If the learner response is incorrect, the same three parameters are remodified in accordance with the above rules. At all times sampling is done with replacement and with a consideration of the saliency (or relative importance) of each parameter. An estimate of the saliency value for each parameter can be derived either logically or empirically.

The instructional system requires that:

1.) All parameters must always have a value.

2.) A given parameter can have different values as it is associated with paradigms for different kinds of behavior.

3.) Some parameter specifications necessitate nesting (it is meaningless to set voice volume if there is no oral component to the display) and hence some parameters are eliminated from consideration at certain times.

The steps that the modification scheme goes through are presented in Table 2. It is hoped that these steps listed in the order of operation will help the reader to conceptualize the somewhat complex, but intuitive model presented here.

Quantitavely, this modification scheme is designed to:

1) Handle the potentially large number of parameters that it must. 2) Make observable changes as opposed to miniscule changes by changing one parameter at a time. 3) Optimize instruction. The operators function so as to maximize improvements while minimizing setbacks. 4) Attentuate the abruptness of changes as the system and the learner accommodate to each other. 5) Adapt to changes (learning or maturation) in the learner over time. This last property can be augmented by systematically letting θ become larger then reduce again by resetting saliency values over time.

Needed Research

Before this modification scheme can be incorporated into an instructional system and implemented for use, certain basic questions must be pursued. First, the relevant parameters must be identified and scaled. This problem is not insurmountable because only manageable parameters need to be used. Additional parameters can be added to the system as we discover them and learn how to work with them.

Experiment must be run to validate the modification scheme. Computer generated data could help demonstrate that this scheme leads to optimization of performance. However, subjects must also be taught in such a system. Different students should end up with different p values. If John is given Sally's p values, he should perform less well than with his own. If John is given Sally's p values, the the values should change to resemble John's original set after some time on the system. These inferences suggest several experiments which are to be carried out.

Evaluation of the entire cybernetic instructional system is being considered. This evaluation will probably result in changes being made in the system rather then resulting in an over-all approval or disapproval of the system. Such data collection is currently only in the planning stages. Some of it must be gathered before any comments about the effectiveness of this modification scheme and of this approach to designing instructional situations can properly be made.

TABLE 1

OPERATORS FOR CHANGING PARAMETER VALUES

P = Value of a parameter of an instructional paradigm.

Pi,n = Value of parameter "i" before learner response number "n".

Operator:

A $\quad P_{i,n+1} = (1 - \theta)\, P_{i,n} + \theta$

B $\quad P_{i,n+1} = (1 - \theta)\, P_{i,n}$

TABLE 2

OUTLINE OF OPERATION OF MODIFICATION SCHEME

1.) The system provides a set of parameters whose values differ among individuals.

2.) The instructional paradigm for each kind of instructional outcome has a subset of parameters associated with it.

3.) Take the subset for the paradigm associated with the objective to be taught.

4.) Establish which parameters are irrelevant to determining the display because of being nested below a parameter which has a present value that makes them superfluous.

5.) Exclude the currently irrelevant parameters from the subset and draw a set of n (where "n" is small, say 3 - 5) parameters. Selection considers the relative saliency of each parameter within the large subset.

6.) Operate * on each parameter in the set of five.

7.) Present the learning trial.

8.) Look at response correctness.

   a.) if correct, return the five parameter values and select a new set of five.

*Since the set of "n" is only returned after a correct response, the operator will be selected so as to move the value in the same direction as on the trial when that value was last manipulated.

TABLE 2 (continued)

b.) if incorrect, reoperate on each parameter (change direction) value in the set of n and go to next trial.

REFERENCES

Cronbach, L. J. How can instruction be adapted to individual differences? In R. M. Gagne (Ed.) _Learning and individual differences._ Columbus, Ohio: Merrill, 1967.

Merrill, M D. Components of a cybernetic instructional system. _Educational Technology._ April 15, 1968, pp. 5 - 10.

Merrill, M.D. Necessary psychological conditions for defining instructional outcome. _Educational Technology_ (In Press, 1970)

FOOTNOTES

[1]Parameter is defined as a characteristic element or constant factor which helps define a particular psychological condition. While the factor is constant, that is must be present, the value this factor assumes may vary.

[2]Values do not refer, in this context, to philosophy but to quantities, amounts, categories, or some other position on some type of metaic scale. A parameter, thus, may assume several values, meaning it specifies some characteristic which must be present but can differ in kind or amount.