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ABSTRACT
              This study tested the hypothesis that high school
students can effectively manage their learning needs in a
computer-assisted instructional system when provided on-task
advisement of their learning achievement in relation to a given
criterion. One hundred and thirty-nine male and female high school
students from a 12th grade course in psychology were assigned
randomly to one of four treatment conditions. The two independent
variables cf management strategy (adaptive control and learner
control) and advisement (with and without) were tested with a
pretest-posttest, two-way factorial design that involved the four
treatment groups. Advisement information was provided to the students
using the Minnesota Adaptive Instruction System. Data analysis
indicated that advisement, using either a program control or learner
control management strategy, resulted in better posttest performance,
less instructional time, and fewer instructional examples than those
same management strategies with no advisement. (Author/MER)

Advisement and Management Strategies

:s Design Variables in Computer-Assisted Instruction

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Advisement and Management Strategies

as 'Design Variables in Computer-Assisted Instruction

Control of the amount and sequence of instructional stimuli has been a recurring problem in the design of computer-assisted learning environments. Methods of control have ranged from those in which the learner plays a direct role in decision-making to more highly sophisticated adaptive systems (Tennyson & Rothen, 1979). The adaptive systems include processes for assessing both the student's skills (for example, general aptitudes, prior achievement, on-task learning progress) and the characteristics of the learning task (difficulty level, content structure, conceptual attributes) so that an initial instructional program can be continuously adjusted to meet on-task student learning needs. However, instructional research (DiVesta, 1975) and applied projects (Steinberg, 1977) dealing with variables of learner control (using rather large or complex learning tasks) have failed to demonstrate that students can make and carry out decisions of content element selection and personal assessment. It would therefore appear that program controlled management systems are necessary for effective computer-assisted instruction.

Given poor student performance with learner control systems consisting of a complex content structure and demanding greater prerequisite knowledge, Tennyson and associates designed (Rothen & Tennyson, 1978) and tested (Park & Tennyson, in press; Tennyson & Rothen, 1977; Tennyson, Tennyson, & Rothen, in press) the Minnesota Adaptive Instructional System (MAIS), which uses a Bayesian statistical method to integrate (a) assignment of a specific treatment based on a premeasure of cognitive ability; (b) an initial

amount of instructional support based on a pretest measure of prior achievement; and (c) adjusted amount of instructional support and sequence based on on-task learning need. Our first purpose in this study was to test the MAIS against a learner control strategy (one in which the student decides when to terminate instruction and begin the posttest). Based on the findings of the Tennyson and Rothen (1977) study, which showed that the MAIS management strategy was significantly more effective than a nonadaptive management strategy, we hypothesized that adaptive control would be more effective than learner control in helping students to learn concept tasks.

While adaptive control systems do make use of modern computing power (Johansen & Tennyson, in press), they do not take into consideration the educational goal of individual responsibility for learning and consequent intellectual development. To address this goal, instructional program strategies have attempted to provide students with post hoc advice about possible remedial instructional help (Bunderson, Note 1). We propose, however, that if students are given meaningful information (advisement) on-task about their own learning development, their own cognitive strategy may further refine the diagnosis and prescription made by an adaptive management system. Thus, advisement as used in this study is a form of information that consists of diagnostic and prescriptive data generated from the MAIS management control system and given to students during the learning process. Operationally, advisement implies several things. First, at the start of their instruction, students are advised of (a) their initial level of knowledge compared to the desired learning criterion (diagnosis), and (b) the amount and sequence of instruction necessary for them to obtain the objective (prescription). Second, students are continuously advised while

on-task of their learning development (updated diagno-.   nd the instructional

needs (updated prescription) necessary for task mastery.

For the independent variable of advisement, we hypothesized that student

performance with advisement would be improved over a conventional computer-

assisted instructional program that lacked advisement. We further hypothesized

that a learner control strategy with advisement would not only be as

effective in student acquisition of the learning task as the adaptive control

strategy (that is, students in both these strategy conditions would surpass

the criterion of mastery) but also that it would be more efficient in terms

of student on-task learning time. An additional hypothesis was that the

interaction of learner control with advisement would be the best treatment

(of the four treatment conditions resulting from the two independent variables)

in terms of both performance and time on-task, whereas the learner control

without advisement condition would be the least effective (that is, students

would not reach mastery).

Method

Subjects

Participants (N = 139) were twelfth grade male and female students from

a psychology class at Eisenhower Senior High School in Hopkins, Minnesota.

Students were assigned randomly to one of four treatment conditions as they

appeared for the experiment. They understood that they would be given

credit for participation and that their teacher would grade their posttest

scores. This contingency was included to stimulate an actual classroom-

related incentive missing from most learner control studies. Without such

a contingency, as Felixbrod and O'Leary (1974) have shown, students in

learner control stituations tend to terminate early and thus learn less.

A strong incentive to master the material -- in this instance, a course

grade -- provides a better comparison between a program control condition,

which relies on a relatively captive audience, and a learner control condition.

Learning Program

Coordinate concepts selected for this study -- positive reinforcement,

negative reinforcement, positive punishment, and negative punishment -- were

drawn from the field of psychology (Tiemann, Kroecker, & Markle, Note 2)

and developed by Tennyson, Tennyson, and Rothen, (in press). Three subordinate

concepts -- stimulus, aversive stimulus, and attractive stimulus -- were included,

in addition to a superordinate concept that dealt with the consequences of

behavior resulting from the stimulus. Examples used in the learning program

and accompanying tests were written according to the concept design strategy

developed by Merrill and Tennyson (1977). Of 88 examples in the learning

program, 40 were used in the instructional lessons (10 per concept), 24

in the pretest, and 24 in the posttest.

Using Tennyson's (in press) revision of the Merrill and Tennyson (1977)

procedures for designing concept learning lessons, the experimental learning

program was developed. First, a printed booklet presented the instructional

directions and the concept definitions with one prototype example per concept.

The directions explained that the purpose of the definitions was to help the

student understand the critical attributes of each concept, whereas the

prototypes were to be used during the instructional presentation to compare

and contrast with the instructional examples. Second, a computerized

instructional program presented the examples in two presentation forms --

expository and inquisitory (Tennyson, Chao, & Youngers, in press). In the

expository presentation form, one example of each concept was displayed

and students were directed to study how each of these examples differed

from the prototype examples. After studying the four expository examples,

students received their remaining examples in the inquisitory presentation

form. Directions for the inquisitory presentation from instructed students

to use the prototype examples when determining the correct classification of

each example. (This procedure helps a student learn to use the prototype in

developing the intellectual skills of generalization and discrimination.)

After each response, students received confirmation on whether their answer

was correct or incorrect. Students in the two advisement groups also received

an update on the number of examples still needed for mastery.

To validate the learning program, we used a formative evaluation procedure

for assessing instructional materials (Tennyson, 1978). Several subject

matter experts first reviewed the definitions and instances. Then, after

appropriate revisions of the definitions and instances, a one-to-one tryout

of each learning program was conducted with six randomly selected students

from the sample population. This was followed by simulation tryouts of

each treatment condition (six students per treatment). Final refinements

on the learning program and computer software were made from this tryout.

Minnesota Adaptive Instructional System

To study the management strategy variable, we used for the adaptive

control strategy the computer-based Minnesota Adaptive Instructional System

developed by Rothen and Tennyson (1978). This computer management system

determines the number of examples each student receives from three parameter

values: achievement level, a mastery criterion (.7), and loss ratio (1.5) --

which is defined as the disutilities associated with a false advance compared

to a false retain decision. The estimate of the student's ability to learn

a concept was characterized in probabilistic terms. From the initial

achievement level, which was determined by the pretest score and the other

two parameter values, the probability was used to decide the initial number

of examples per concept that the student needed. This probability figure

was adjusted according to the student's on-task performance level, then

the prescribed number of examples was modified. Student performance on each

concept was calculated separately with a criterion level set at 1.0 on the

initial assessment. That is, if the student answered all six examples

of any concept correctly on the pretest or the initial part of the learning

program, he or she received no more examples of that concept unless it was

needed for discriminating coordinate concepts. (For a complete review of

this response-sensitive procedure, see Tennyson and Park, 1980; or Park

and Tennyson, in press.) If the students failed to achieve total mastery

on the initial assessment, the criterion level was adjusted to suggest a

prior distribution slightly greater than .5 to the region above the criterion

level: $P = (\pi \geq \pi_o / \underline{x}, \underline{n}) > .5$, where π_c is the objective's criterion level,

π is the student's true achievement level, $\underline{n}$ is test length, and $\underline{x}$ is the

student's score (Tennyson & Rothen, 1979).

Treatment Programs

The two independent variables of management strategy (adaptive control and

learner control) and advisement (with and without) were tested with a

pretest-posttest, two-way factorial design that involved four treatment

groups. In the adaptive control strategy, the number of instances presented

to each student was based on the student's pretask and on-task performance

in relationship to the learning objective, and the sequence of instances

was presented according to the student's response pattern to the given example. Following the pretest, students in the adaptive control condition were given program directions and informed that they would receive a posttest at the conclusion of the instruction. In the learner control strategy, the students themselves decided whether to continue receiving examples (and if so, which concept they wanted to see next) or to go to the posttest. Students were informed in the program directions that they had complete control on the amount and sequence of instruction.

For the second independent variable, advisement, the two conditions (with and without advisement) were operationally designed as follows: in the advisement condition for adaptive control, students were informed, following the pretest and after each response, of the number of examples needed to reach mastery (diagnosis and prescription information determined by the MAIS). Program directions for the adaptive control strategy informed students that advisement was determined according to their individual learning development in relation to mastering the concepts; in the learner control strategy, they were told that it would aid them in deciding the amount and sequence of instruction. The adaptive control condition without advisement did not provide students with information on their learning progress, nor did the learner control condition without advisement provide students with diagnostic help. Four computer-based instructional treatment programs were developed from these four conditions:

Program 1. Students had control over the amount and sequence of instruction. Advisement was given following the pretest and updated after each response (Group 1: learner control with advisement).

Program 2: Control of the amount and sequence of instruction was determined

by the computer-based management program. Students were advised of their

learning progress at the completion of the pretest and after each response

(Group 2: adaptive control with advisement).

Program 3: Students selected the amount and sequence of instruction but

without advisement on their learning needs (Group 3: learner control

without advisement).

Program 4: The amount and sequence of instruction were controlled by the

computer-based management program, and no advisement was given students

(Group 4: adaptive control without advisement).

Facilities

The experiment was conducted in a small room in the math-science resource

center at Eisenhower Senior High School. Two ADDS 780 cathode ray teletype

computer terminals were used for the study. Each terminal, operating at 30

characters per second, was connected on-line by telephone to a Control Data

6400 computer at the University of Minnesota.

Procedure

As students reported for the experiment, each was assigned to a treatment

program. The experimenter turned on the terminal and entered each student's

treatment program number. After receiving direction on operating the terminal,

students were first administered a 24-item pretest. When the pretest was

finished, they received a print copy of the four concept definitions and

prototype examples from the experimenter and told that they should refer

to these definitions and prototype examples during the learning program.

After studying the definitions and prototype examples, students raised their

hands to indicate readiness to study the examples in the learning program.

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The experimenter entered the appropriate command on the terminal for students to begin the learning program. After a student classified an example in the learning program, he or she received feedback on whether the classification was correct or incorrect. When each student finished the learning program, the experimenter took the definition and prototype example sheet and entered the appropriate command on the terminal for the posttest to begin. All student entries were single-letter alphanumeric responses to multiple-choice questions. The tests and learning program required no other entries by the student. After the students had finished, the experimenter thanked them and they left the experiment room. Others were then signed on to the terminal.

Results

The data analysis consisted of a multivariate analysis with univariate tests on each dependent variable followed by mean comparison tests (Student-Newman--Keuls). Dependent variables included the correct score on the posttest, learning program time (the measured time period in which students interacted with the learning task, excluding pretest or posttest times), and number of learning program examples. The tests for homogeneity of regression of within-class and between-class linearity were nonsignificant ($p > .05$).

For the multivariate test, we used as dependent variables posttest score and time on-task. The main effect of management strategy was significant, U (1, $\frac{1}{2}$, 137) = .24, $p < .001$. The test on the second main effect, advisement, was likewise significant, U (1, $\frac{1}{2}$, 137) = .95, $p < .05$. The interaction test between the two independent variables was nonsignificant ($p > .05$). Following are the univariate test results on each of the dependent variables.

Posttest Correct Score

The analysis of variance on the posttest correct score (Table 1) showed a difference between the two management strategies, F (1, 135) = 24.07, p < .001. Students in the learner control condition (M = 16.9, 70% correct) had a posttest score 4 points lower than students in the adaptive control condition (M = 21.1; 88% correct). For the main effect of advisement, the F test was significant, F (1, 135) = 16.54, p < .001, with the group receiving advisement (M = 20.8; 86% correct) having scores more than 3 points higher than groups receiving no advisement (M = 17.3; 72% correct). The Student-Newman-Keuls multiple range test was used to compare posttest correct mean score differences between the four groups. At the .01 level, Group 3 (learner control without advisement) had the lowest posttest score, while the other three groups were equal. All groups achieved mastery except this one.

Criterion for mastery was set at .7 on the posttest. Group 1 (learner control with advisement), Group 2 (adaptive control with advisement), and Group 4 (adaptive control without advisement) achieved mastery at the .82, .90, and .86 levels -- 12 to 20 percent above criterion. Group 3 did not reach criterion, falling short by 13 percent (.57).

Insert Table 1 about here

Time On-Task

Average time spent on the pretest was 7.6 min; time spent on the posttest averaged 9.3 min. No significant differences appeared between groups in the pretest and posttest times (p > .05). The univariate test on the main effect

for management strategy was significant, F (1, 135) = 89.18, p < .001.

Students in the two learner control groups spent 6 min (M = 10.0 min) less

than those in the adaptive control groups (M = 16.1 min). For the main

effect of advisement, the F test was likewise significant, F (1, 135) = 8.76,

p < .05, with the two groups receiving advisement spending 2.3 min more on

task (M = 14.3 min) than those groups not receiving advisement (M = 12.0 min).

A comparison of mean time differences for the four groups by the Student-

Newman-Keuls multiple range test showed that Group 3 spent significantly

less time (p < .01) than Group 1. By the same token, Group 1 spent less time

(p < .01) than Group 2 or Group 4, both of which equalled (p > .05).

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Insert Table 2 about here

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Number of Examples

The difference in learning time is directly related to the number of

examples presented in the instruction. The analysis of variance test on

number of examples for the management strategy main effect was significant,

F (1, 135) = 168.37, p< .001, with the learner control groups using a mean

difference of twelve fewer instances (M = 15.2) than the adaptive groups

(M = 27.0). For the main effect of advisement, F (1, 135) = 35.18, p< .01,

the groups receiving advisement (M = 23.5) used an average mean of five more

examples than the groups without it (M = 18.7). The Student-Newman-Keuls

multiple range test showed that Group 3 studied the fewest number of examples

(p < .05), Group 1 the next least amount (p <.05), and Groups 2 and 3 (p> .05)

more than Groups 1 and 3 (p >.01). In other words, while students in the

learner control without advisement condition used, on the average, only

25 percent of the possible examples, the learner control with advisement condition used 51 percent. This was 17 percent less than the two adaptive control conditions (both at 68 percent).

Discussion

Research on learner control variables has not produced instructional design variables that are generic. That is, learner control seems to be a useful management format once the correct contingency is identified, but this seems to be successful only in highly limited and well-defined occupational areas (Steinberg, 1977). Too often, contingencies associated with school-related learning, such as grades, praise, or rewards, vary in relationship to individual variables, such as sex, age, race, and home environment. This frequently results in variables and conditions too confusing for practical application or theoretical development. One purpose of this study was to introduce a variable to the basic computer-assisted learner control manage- ment strategy unlike that of previous research variables. It dealt with actual on-task learning development -- advising students of both their learning progress (diagnosis) and their individual learning need (prescription) to help them master the learning objective. Students would thus have meaningful information on which to make judgments about the amount and sequence of instruction.

As operationally defined, the variable of advisement was highly significant in providing students in the learner control condition with meaningful information with which to make appropriate decisions about acquisition of the coordinate concepts. On the posttest, students in the learner control with advisement condition (Group 1) did as well as students in the two adaptive control conditions (Groups 2 and 4, each over 80 percent correct).

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The significance of this result is apparent in contrast to performance in the learner control without advisement condition (Group 3), in which students responded to only 58 percent of the posttest items correctly (identical to the pretest). This outcome of the learner control without advisement condition is consistent with previous research (Tennyson, in press), which has shown that even with a strong contingency such as a grade, students learn little / from instruction; research has furthermore. shown that no matter what level of on-task attainment is reached, all students leave instruction at approximately the same time (see Tennyson & Rothen, 1979).

The dependent variable of time is important to consider in the study of learner control management strategies because students in a learner control condition consistently leave instruction before mastering the objective (Tennyson, Tennyson, & Rothen, in press). In contrast to this basic finding, students in the learner control group which received advisement stayed on-task long enough to obtain mastery. In fact, they were on-task approximately 39 percent longer than the students in the conventional learner control condition. It was our thesis that if students in a learner control strategy were given advisement in the form of adaptive diagnostics and prescriptions, they would master the objective in less time and use less instruction than in a program-controlled adaptive system. The assumption was that the cognitive strategy that students used in learning would further refine the adaptive information. The findings support this notion. The two conditions using the adaptive information (adaptive control and learner-adaptive control) had identical posttest-score means, but the learner control with advisement condition showed significant decreases in on-task time (22 percent less) and amount of instruction (25 percent less).

In conclusion, a learner control condition can be a valuable instructional management system, especially for computer-based instruction, if students receive sufficient information about their learning development -- information that continuously shows them what progress they have made toward mastery of the objective and provides meaningful advice on appropriate stimuli necessary to obtain it.

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Table I

Mean and Standard Deviations for Posttest Correct Scores

Advisement	Management Strategy	
	Learner Control	Adaptive Control
With	Group 1:	Group 2:
M	19.9	21.6
SD	3.3	3.2
Without	Group 3:	Group 4:
M	13.9	20.6
SD	3.3	3.7

Note: Maximum posttest score = 24

Table II

Mean and Standard Deviations

for Time On-Task and Number of Examples

Advisement	Management Strategy			
	Learner Control		Adaptive Control	
	Time	Number	Time	Number
With	Group 1:		Group 2:	
M	12.5	20.2	16.0	26.7
SD	5.5	9.0	4.4	5.6
Without	Group 3:		Group 4:	
M	7.7	10.1	16.2	27.3
SD	6.7	8.7	3.0	4.2

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