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ABSTRACT

A study was conducted to investigate learner control of instruction in contrast to response sensitive branching algorithms with respect to two specific types of instructional decisions: (1) whether a student should enter and study a particular instructional module given his score on an associated diagnostic pretest; and (2) when a student should terminate practice on each of the problems associated with a concept or principle in an instructional module. It was hypothesized that students given control over the number of modules studied would select fewer modules and that given learner control over tests, students with learner control in instruction would select more modules for study than would students under program controlled instruction. The context of the experiment was a computer-assisted program in precalculus mathematics called "Math-S". Two topics of the program: exponents and dimensional analysis, were covered. The program was run on an IBM Instructional System. Complete data was collected on 97 college physics students. The complete experiment constituted a 2 x 2 design: learner control and program control in diagnostic tests, and learner and program control in the instructional modules. All subjects were administered a pretest and a posttest. Pretest score did not interact with the diagnostic test variable in either exponents or dimensional analysis. Posttest scores were found to be insensitive to diagnostic test variable. No interactions with pretest scores found in either exponents or dimensional analysis. It is concluded that while learner control may well have a facilitative role in computer assisted instruction, further research is required to define the characteristics and limitations of that role. (CK)

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Program vs. Learner Control of Selection of Instruction and Amount of Practice in Computer-Assisted Instruction

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There has been considerable recent interest in possible advantages of learner control in computer-assisted instruction. While the term "learner control" has been only vaguely defined, it is generally understood to refer to a situation in which decisions as to a student's route through an instructional program are made by the student himself rather than being predetermined or made on the basis of a preprogrammed response sensitive algorithm. Most research in the area has concentrated on questions of sequencing and there has been little concern with the relative effectiveness of learner control and response sensitive branching schemes for determining the amount of instruction which a student receives.

The purpose of this study was to investigate learner control of instruction in contrast to response sensitive branching algorithms with respect to two specific types of instructional decisions: (1) whether a student should enter and study a particular instructional module given his score on an associated diagnostic pretest; and (2) when a student should terminate practice on each of the problems associated with a concept or principle in an instructional module. These two instructional techniques were evaluated in terms of student performance behaviors during the course of the program, posttest scores and responses for an attitude scale. It was hypothesized that students given control over the number of modules studied would select

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fewer modules than would students under program control and that their posttest scores would be correspondingly lower. It was further hypothesized that given learner control over tests, students with learner control in instruction would select more modules for study than would students under program controlled instruction. No other specific hypotheses were made with regard to amount of practice within modules.

A fairly long instructional sequence was employed since it was anticipated that students might need to learn to use learner control options appropriately. It was also anticipated that student response to learner control might vary as a function of the student's facility with the subject matter. Therefore, interactions between the experimental treatments and pretest score were also investigated. The experiment was a partial replication of a previous study utilizing the same instructional program and learner control options (Judd, Bunderson, & Bessent, 1970).

Method

Instructional Program

The context of the experiment was a computer-assisted instruction program in precalculus mathematics written by Authella Smith. The program, called "MATH-S," was a revised version of a previous program, also authored by Mrs. Smith, entitled "Preskills." For the purposes of this paper, the revisions of interest were the addition of a variety of learner control options. The MATH-S control program was altered for this experiment to allow the learner control options of interest to be replaced with programmed control in the appropriate experimental treatments. The complete program covers three topics: exponents, logarithms, and dimensional analysis. The logarithms section was excluded from this experiment at the request of the course instructors.

The program was run on an IBM 1500 Instructional System using both cathode ray tube and typewriter terminals, equal numbers of subjects being assigned to each terminal type. Due to the small number of subjects in each cell of the design and the absence of relevant interactions between terminal types and the pretest covariable, subjects using the two types of terminals were grouped together in the data analysis. Both terminal types were supplemented with image projectors.

The program was divided into 17 modules, 12 in exponents and 5 in dimensional analysis. Each module was preceded by an embedded diagnostic test with an average of 5 test items per test. In instructional modules, the rules and concepts and their corresponding examples were presented by the cathode ray tube (or typewriter) and image projector. Following each expository segment, the student was given a number of practice problems where each problem contained one or more questions pertaining to a particular numeric expression. The numeric values in the expressions were selected or generated so that a student could repeat each problem a number of times with different values. The program required an average of approximately 15 hours for completion, about 11 hours for exponents and 4 for dimensional analysis.

Subjects

The initial subject sample consisted of approximately 160 students drawn from University of Texas introductory physics classes over a 2-semester period. Of these, 120 began the program. There was some attrition and some data loss due to experimenter errors. Complete data was available for 97 subjects (Ss) completing exponents and 72 completing both exponents and dimensional analysis.

Experimental Design

As was previously mentioned, the purpose of the study was to contrast two learner control options with analogous conventional response sensitive branching algorithms. The first option concerned the action taken following a diagnostic test with regard to whether or not the subject studied the corresponding instructional module. Ss with learner control (LC) on this variable were given their score on the test and advised as to whether they had or had not met the objective of that module. Meeting the objective required 100% correct performance on the test. The subject was then free to enter or skip the module, as he wished. Ss under program control (PC) on this variable were routed into the module if they demonstrated less than perfect performance on the test. Otherwise, they were skipped to the next test.

The second option investigated concerned the number of times Ss repeated each practice problem (with different numeric values) within the instructional modules. For Ss with LC on this variable, each practice problem was repeated until the subject indicated that he was ready to proceed to the next problem by typing an "n" while in or at the end of the problem. Students under PC were required to make two errorless passes through a problem, answering all questions in the problem correctly, before being routed to the next problem.

In addition to the control options discussed above, a number of options were available to all students. Ss could skip an individual diagnostic test item (scored as an error), skip a question in a practice problem (scored as an error), jump out of the diagnostic test into the instructional module, access a glossary or a set of drill programs on prerequisite skills, and enter a comment. The program normally allowed learner control over the sequence of modules but sequence was fixed in the order considered optional for purposes of the experiment.

The complete experiment thus constituted a 2 x 2 design: learner control and program control in diagnostic tests, and learner and program control in the instructional modules. Due to the fact that many more students completed the exponents topic than both exponents and dimensional analysis, the two topics were treated separately statistically. The final set of performance and posttest data consisted of 24 to 25 Ss per cell for exponents and 17 to 19 Ss per cell for dimensional analysis. The performance and posttest data were analyzed through the use of linear regression models using pretest scores as a covariable.

Experimental Procedure

All Ss were administered a pretest during a regular class period. This was a 43-item multiple choice test; 30 items on exponents and 13 on dimensional analysis. Each test item was keyed to a specific objective. Two parallel forms of the test were available and Ss were randomly assigned to form A or B. At the time of the posttest, each subject was administered the alternate of his pretest form. Ss scoring less than 85% on either the exponents or dimensional analysis pretest were strongly advised to take the program.

A subject who elected to take the program on one or both topics was randomly assigned to one of the experimental treatments when he came to the laboratory for his first study session. He was then given instruction on the operation of the terminal and in the learner control options and/or program control characteristics of his treatment. Ss worked through the program on an ad lib basis in one or two hour blocks. Proctors were available in the terminal room at all times. Approximately 12 weeks were allowed for all Ss to complete the program. When a subject completed his last work session, he was asked to fill out an attitude questionnaire. Group posttests were scheduled just prior to the end of each semester.

Results

Even though the experiment constituted a 2 x 2 design, the conventional analysis of such a design, tests of main effects and interactions was not considered to be appropriate for the within-program performance data. In general, only the main effect was examined for the pertinent variable. One simple effect was examined on the basis of a prior hypothesis. Both main effects and their interaction were examined for posttest scores. The assumption of parallel slopes for the dependent variables' regression on pretest score was tested in all cases prior to a test for mean differences. This provided a check for any interactions between subject entry behavior and the independent variables of interest. Only main effects were examined for the attitude scale data.

Learner vs. Program Control in Diagnostic Tests

The dependent variable selected to evaluate within-program performance for the diagnostic test option was the number of modules which each subject studied. It will be recalled that this would be equal to the number of diagnostic tests failed for PC Ss and at least correlated with the number of tests failed for LC Ss.

Pretest score did not interact with the diagnostic test variable in either exponents or dimensional analysis. LC and PC Ss did not differ in number of modules studied in the exponents topic, the means being 3.56 and 3.43 respectively. As a supplemental analysis, the number of diagnostic tests failed by the two groups were contrasted. Again, there was no interaction with pretest score in either exponents or dimensional analysis. LC Ss failed slightly more tests than did PC Ss (3.96 as opposed to 3.45) but the difference was not significant. In dimensional analysis, following more experience with the program and with the control options, LC Ss elected to study significantly fewer modules ($F = 22.30$, $df = 1/69$, $p < .0001$) than were assigned the PC Ss (1.67 as opposed to 2.89). This was despite the fact that the LC Ss continued to fail more diagnostic tests (3.45 as opposed to 2.92), a difference which approached significance ($F = 2.31$, $df = 1/69$, $p = .13$). Looking at both analyses in both sections of the program, we may conclude that there was a tendency for LC Ss to select fewer failed modules for study and that, although slight at first, this tendency increased with their experience with the program.

Posttest scores were found to be insensitive to the diagnostic test variable. There was no interaction with pretest score nor any main effect in either exponents (21.79 for LC and 22.29 for PC) or dimensional analysis (9.13 for LC and 8.95 for PC).

It will be recalled that it had been hypothesized that given LC in diagnostic tests, Ss who also had LC in instruction would select more modules for study than would Ss who had PC in instruction due to the relative aversiveness of program controlled instruction. Analysis of this simple effect found small differences between these two groups in the anticipated direction in both exponents (4.04 for LC and 3.08 for PC) and dimensional analysis (1.79 for LC and 1.53 for PC) but in neither case were the differences significant. These small apparent differences can be most parsemoniously attributed to the fact that the LC Ss failed more tests than did the PC Ss. In dimensional analysis, the mean number of failed tests was 3.79 for LC and 3.06 for PC. This difference was significant ($F = 4.33$, $df = 1/33$, $p = .045$). The exponents data presented the only instance in which pretest score interacted with a treatment variable ($F = 3.58$, df - 1/44, $p = .065$). While number of failures was inversely related to pretest score for both groups and while LC Ss had consistently higher failure rates than the PC Ss, there was relatively little difference between groups for Ss with high pretest scores and a relatively large difference between groups for Ss with low pretest scores.

In summary, it must be concluded that the assumed aversiveness of program controlled instruction did not result in PC Ss selecting fewer modules for study than their LC counterparts.

Only one of the eleven items on the attitude scale differentiated between diagnostic test LC and PC Ss. Item number 7 noted that different Ss had been given different degrees of control over the program and also pointed out that increased control required the subject to make more decisions himself. The subject was asked if he would rather have had more or less control. Ss responded by selecting one of five ordered statements. The scale was collapsed to three levels for analysis. A chi square test for the 84 Ss who completed the questionnaire indicated significantly more LC Ss than PC Ss wanted <u>more</u> control over the program ($p < .10$).

<u>Learner vs. Program Control in Instruction</u>

The selection of a dependent variable to evaluate within-program performance in the instructional modules posed particular difficulties.

The obvious measure would be the number of times practice problems were repeated but LC Ss could jump from the middle of a practice problem to the next problem without completing the first problem. Problems were therefore considered to be too gross a unit for evaluation purposes and the measure selected was a subject's total number of responses divided by the number of questions he encountered. There were five Ss in exponents and six in dimensional analysis who studied no modules at all. Since these Ss encountered zero questions, they were deleted from the instructional variable analysis, leaving 92 Ss in exponents and 67 in dimensional analysis.

No interactions with pretest scores were found in either exponents or dimensional analysis. LC Ss were found to have somewhat higher number of responses per question (9.07) than the PC Ss (5.78) in exponents. This difference was marginally significant (F = 2.88, df = 1/89, p = .093). The trend was much more pronounced in dimensional analysis with LC Ss having a mean of 10.75 responses per question as contrasted with a mean of 5.31 for the PC Ss (F = 18.31, df = 1/63, p = .0001). Again, posttest scores were insensitive to these performance differences. There were no interactions with pretest scores and only the smallest posttest score differences between groups: 21.19 for LC and 22.88 for PC in exponents; 9.03 for LC and 9.06 for PC in dimensional analysis.

Only one item on the attitude scale differentiated between instructional LC and PC Ss. Item 5 pointed out that the computer could "understand" the subject's answers only if they were entered in the correct form and asked if the subject found the program to be too restrictive. The subject selected his answer from a four-level scale, collapsed to three levels for analysis.

A chi square test indicated that more LC Ss than PC Ss found the program to be too restrictive ($p < .02$).

Conclusions and Implications

In the context of this particular program, learner control would appear to be a mixed blessing. After some experience with the program, subjects' decisions appeared to be more efficient than decisions made by the branching algorithm with respect to whether or not to study instructional modules. Learner control subjects studied significantly fewer modules in dimensional analysis than were assigned the program control students but posttest scores did not differ between the two groups. Contrary to expectation, the prospect of being under program control in an instructional sequence apparently did not dissuade subjects from selecting as many modules for study as were selected by subjects with learner control in instruction. With respect to decisions regarding the amount of practice in instructional modules, however, students were apparently less efficient than the corresponding algorithm. Learner control subjects expended significantly more effort in practice than did program control subjects but posttest scores did not differ between groups. None of the presumed affective advantages of learner control were indicated by subject responses to the attitude scale.

While learner control may well have a facilitative role in computer-assisted instruction, further research is definitely required to define the characteristics and limitations of that role. A consistent problem with the type of research described in this paper concerns the limitations in generalizing to other instructional programs. While learner control may prove to be more efficient than a particular branching algorithm, the basis for this difference may lie in the use of an invalid algorithm rather than any intrinsic advantage of learner control. While acknowledging that students may have to learn the efficient use of some types of learner control through practice, it is suggested that small, well-controlled laboratory studies of relevant control options in which specific performance and affective measures are examined, are required prior to any generalizations concerning the utility of learner control in practical instructional programs.

Reference

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