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BRIEF RESEARCH REPORT

Control of Practice and Level of Feedback in Computer-Based Instruction

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This study investigated the effect of type of control and level of feedback during computer-based instruction. Subjects completed a computer lesson about the microscope that presented either mandatory or optional practice questions. Practice was accompanied by either elaboration feedback, correct-answer feedback, or no feedback. Results indicated that level of feedback had a significant effect on achievement and attitudes. Implications for including feedback in computer-based instruction are discussed. © 1995 Academic Press, Inc.

Educational technologists who design computer-based instruction (CBI) are faced with decisions concerning which features of the medium should be included to maximize student learning. These decisions often are based on how CBI can be designed to meet the individual needs of students. Two factors related to individualization in CBI are learner control and feedback.

According to Hannafin (1984), "one of the most powerful and important features of the computer is the virtually unlimited range of instructional control options available to designers" (p. 6). A variety of control options can be given to learners including control over pace, sequence, practice, item difficulty, and context. While CBI can allow students the opportunity to make instructional decisions, research does not provide conclusive evidence that giving control to students will result in increased learning or motivation (Klein & Keller, 1990).

In addition to learner control, another important element in designing CBI is feedback. Feedback is a unit of information with two components, verification and elaboration (Kulhavy & Stock, 1989). Verification is the simple, dichotomous judgment that an initial response was right or wrong. Elaboration consists of all substantive information contained in a feedback message. Elaboration can be of three types (task specific, instruction-based, or extra-instructional). Research suggests that elaboration feedback produces greater effects for learning than verification feedback (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991).

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The purpose of the current study was to investigate the effect of type of control and level of feedback on achievement, attitude, and selection of optional practice in a CBI lesson.

METHOD

Design and Subjects

A 2 × 3 posttest-only, control group design was used for this study. The independent variables were type of control (program or learner) and level of feedback (elaboration, correct answer, or none). The dependent variables were achievement and attitude. Data for selection of optional practice were also collected for subjects under learner control.

Subjects were 210 junior high school students from a suburban, middle-class neighborhood. Students participated as part of their regular science class and received a grade based on their achievement.

Materials

Six computer programs were developed for this study using Applesoft Basic. Each program included instruction on the parts, functions, and use of a compound, light microscope. The lesson was part of the regular science curriculum for seventh graders at the host school. The content was divided into two units of information; each unit was approximately 1000 words in length. Unit 1 covered the parts and function of the microscope. Unit 2 presented the steps and rules for using a microscope in class. The program presented an introduction and ten information segments that included two to four screens of text. Each computer lesson presented information in exactly the same manner.

Computer lessons differed in respect to how practice was presented. After each segment of information, lessons under program control displayed three mandatory practice questions. Lessons under learner control presented the option of viewing these three practice questions. All practice questions used a five-alternative, multiple choice format. A total of 30 practice questions were included in the lesson for mandatory or optional viewing.

Lessons also differed in respect to the level of feedback presented after each practice question. Feedback was based on the work of Kulhavy and Stock (1989) and directly related to the three levels of feedback under study (elaboration, correct answer, and no feedback). Each level of feedback was displayed exactly the same for either program or learner control conditions.

Under the no-feedback condition, subjects were not shown any feedback for the practice questions. After a subject answered a practice question, the program automatically continued with the next question or screen of text. Under the correct-answer condition, the subject's response was verified as correct or incorrect and the question with the correct answer appeared on the screen. Finally, under the elaboration condition, the subject's response was verified and the question with the correct answer and a short explanation appeared on the screen. Each explanation contained extra-instructional information to help a student understand why an answer was correct. For example, elaboration feedback for the stage clips stated, "The stage clips are called stage clips because they are located on the stage of the microscope and hold the slide like a paper clip holds paper." In both the correct-answer and elaboration conditions, a subject could study the feedback as long as she wished before continuing with the program.

In addition to the CBI, a diagram of a compound, light microscope was developed. This diagram represented the type of microscope that students would use in their classes. Each of the main parts of the microscope were labeled with a number. Each part was referred to by name and number in the computer lesson. Copies of the diagram were sheathed in plastic to prevent tampering with the numbers and note-taking during the lesson.

Procedures

This study was conducted using 210 students enrolled in nine, seventh-grade science classes. Prior to the experiment, all subjects were blocked by sex to ensure equal distribution of males and females and then randomly assigned to one of six experimental conditions. Subjects participated in small groups of 16 students per session in a computer laboratory at their junior high school. All treatment conditions were present at each session.

Upon arrival to the computer laboratory, each subject was assigned a computer terminal. Each computer had a separate disk already installed and was ready to begin the instruction. A diagram of the microscope was located next to each computer. After all students were seated, the experimenter gave a short introduction on general procedures. Subjects were told that instructions were included in the program, but they were not told that the programs were different. Subjects were also told that a test measuring their understanding of the material would be given and would be part of their overall science grade. Subjects then proceeded with their individual programs; they completed each unit of the lesson on two separate days. Subjects completed a posttest and attitude survey in their regular classroom one day after finishing the computer lesson. A pilot study of 60 subjects conducted at the host school indicated that the materials and procedures were appropriate for the seventh grade population.

Criterion Measures

Criterion measures for this study were achievement and attitude. Data for selection of optional practice were also collected for subjects in the learner control conditions.

Achievement was measured using a 30 item, paper-and-pencil posttest. This test consisted of three sections on the parts, functions, and use of the microscope. The first section included a diagram of the microscope and nine items that required identification of each part. Subjects were provided with the same diagram of the microscope used during instruction, but a different number was used to label each part. Subjects were required to write the number corresponding to each part on blank lines provided on the diagram. The Kuder–Richardson reliability of the diagram section of the posttest was .76. The second section of the posttest consisted of nine multiple choice questions on the functions of each part. The third section consisted of 12 multiple choice questions on the rules for using a microscope in class. The multiple choice questions on the posttest were identical to those presented in the computer lesson but were displayed in a different order. The Kuder–Richardson reliability for the multiple choice items on the posttest was .88.

Attitude was measured using a nine item, Likert-type survey. This paper-and-pencil instrument included items measuring subject enjoyment, confidence, and continuing motivation. An additional open-ended question asked subjects for their comments about the computer lesson.

Data for selection of optional practice were automatically recorded by the computer for each learner control subject. Each record registered the item number and whether the optional practice question was selected.

RESULTS

Achievement

Mean scores and standard deviations for achievement are given in Table 1. Overall achievement consisted of a subject's total combined score on each of the three sections of the posttest. These data indicate that the mean score on the total posttest was 18.54 for subjects who received elaboration feedback, 16.79 for subjects who received correct-answer feedback, and 18.00 for those who received no feedback. The mean score

TABLE 1
MEANS AND (STANDARD DEVIATIONS) FOR ACHIEVEMENT[a]

	Level of feedback			
Type of control	No feedback	Correct answer	Elaboration	Total
Program control				
Diagram	6.66 (2.06)	5.49 (2.64)	6.83 (1.77)	6.32 (2.25)
Functions	5.69 (1.83)	4.83 (2.50)	5.17 (1.85)	5.23 (2.10)
Rules	6.06 (2.50)	6.49 (2.61)	7.03 (2.49)	6.52 (2.54)
Overall	18.40 (2.19)	16.80 (2.58)	19.06 (2.14)	18.09 (2.30)
Learner control				
Diagram	6.71 (2.32)	5.66 (2.06)	6.69 (2.10)	6.35 (2.20)
Functions	5.09 (2.06)	4.74 (2.02)	5.09 (1.56)	4.97 (1.88)
Rules	5.89 (2.39)	6.37 (2.57)	6.43 (2.76)	6.23 (2.56)
Overall	17.60 (2.25)	16.77 (2.22)	18.03 (2.25)	17.47 (2.24)
Grand total	18.00 (2.22)	16.79 (2.40)	18.54 (2.20)	17.78 (2.27)

[a] Maximum possible scores for the diagram, functions, and rules sections were 9, 9, and 12, respectively.

was 18.09 for subjects in the program control conditions and was 17.47 for those in the learner control conditions.

MANOVA was used to test for differences between groups on overall achievement. Alpha was set at .05 for all statistical tests. Results revealed that level of feedback had a significant effect on overall achievement $F(6,402) = 3.93$, $Ms_e = 94.94$. Results did not reveal a significant main effect for type of control, nor an interaction between level of feedback and type of control.

MANOVA was followed by separate univariate analyses on each of the three sections of the posttest. Results revealed that level of feedback had a significant effect on the diagram portion of the posttest $F(2,204) = 6.55$, $MS_e = 61.90$. A Scheffé pairwise comparison test revealed that subjects who received elaboration feedback ($M = 6.76$) and those who received no feedback ($M = 6.69$) performed significantly better on the diagram portion of the posttest than those who received correct-answer feedback ($M = 5.57$). No other significant results were found were follow-up tests were conducted.

Attitude

Table 2 shows means for responses to the 9 Likert-type items on the attitude survey. The 10th item was an open ended opportunity to make comments, which was almost completely ignored by subjects. Mean responses ranging from 2.58 to 3.32 suggest that subjects had rather neutral attitudes toward the program.

MANOVA was used to see if a difference existed between treatment

TABLE 2
MEANS FOR ATTITUDE BY LEVEL OF FEEDBACK[a]

Item	Level of feedback			
	No feedback	Correct answer	Elaboration	Total
Wanted more info about answers	2.53	2.97	2.67	2.72
Wanted more info about correct answers	2.47	2.94	2.83	2.75
Rather teacher gave lesson	3.06	3.66	3.26	3.32
Enjoyed computer lesson	3.09	3.33	3.01	3.14
Learned a lot	2.73	2.97	2.64	2.78
Wanted to use computer again	2.60	2.93	2.57	2.70
Felt confident	2.68	2.78	2.70	2.72
Felt in control	2.67	2.79	2.74	2.73
Wanted more control	2.51	2.79	2.44	2.58

[a] Responses ranged from 1 = strongly agree to 5 = strongly disagree.

groups on overall attitude. MANOVA was followed by univariate analyses for each question on the attitude survey. Results revealed that level of feedback had a significant effect on overall attitudes, $F(18,386) = 21.78$, $MS_e = 61.62$. Results did not reveal a significant main effect for type of control, nor an interaction between level of feedback and type of control.

Follow-up univariate analysis indicated that level of feedback had a significant effect on three of the items on the attitude survey: (1) I would have liked more information about my answers $F(2,202) = 4.26$, $MS_e = 7.92$; (2) I would have liked more information about the correct answers, $F(2,202) = 3.99$, $MS_e = 7.40$; (3) I would rather have the teacher give the lesson, $F(2,202) = 5.27$, $MS_e = 14.24$. A Scheffé pair-wise comparison test revealed that subjects who did not receive feedback were significantly more likely to agree with these three items. No other significant results were found for attitude.

Selection of Optional Practice

Subjects in the learner control conditions had the option of selecting practice throughout the computer program. Results indicate that 21 of the 105 learner control subjects (20%) completed all 30 practice items. The mean number of practice items selected by subjects in the learner control conditions was 19.48. Learner control subjects who received elaboration ($M = 19.66$) selected about the same amount of practice as those who received no feedback ($M = 19.40$) or correct-answer feedback ($M = 19.38$).

Out of the total of 30 practice items, there were 9 optional diagram questions, 9 function questions, and 12 rule questions. Subjects in the

learner control conditions selected an average of 6.47 diagram questions, 4.56 function questions, and 8.35 rule questions. No significant differences were found between feedback conditions for selection of optional practice.

DISCUSSION

The purpose of this study was to investigate the effect of type of control and level of feedback on achievement, attitude, and selection of optional practice. Results indicate that level of feedback had a significant effect on achievement. Subjects in the elaboration feedback condition and those in the no feedback condition performed significantly better than those in the correct-answer feedback condition on the diagram. Furthermore, the achievement of those who received elaboration feedback was not significantly different than those who received no feedback.

A possible explanation for these findings is that subjects who received elaboration feedback were given extra-instructional (Kulhavy & Stock, 1989) information on what each part of the diagram resembled and explanations of how a part got its name. This additional information may have helped subjects in this condition to remember the parts of the microscope. It is also possible that subjects who did not receive feedback were more engaged in finding information in the text. These subjects could not rely on a feedback message to provide any information, so they were required to read the text more thoroughly than other subjects. Subjects who received correct-answer feedback were not required to spend additional effort to find out about their answers because they were told the correct answer. However, the feedback message for these subjects did not provide any additional information to help them correct their mistakes, nor did it provide any elaboration.

Level of feedback also had a significant effect on student attitude toward the lesson. While most subjects were somewhat neutral about the lesson, subjects who did not receive feedback were significantly more likely to agree with the statements (1) I would have liked more information about my answers, (2) I would have liked more information about the correct answers, and (3) I would rather have the teacher give the lesson.

The fact that subjects who did not get feedback wanted more information is not surprising. Subjects in the no feedback condition were neither given verification of their answers nor any explanations about their answers. The result that subjects who did not receive feedback were significantly more likely to indicate a preference for teacher-based instruction is somewhat misleading. Subjects in all conditions disagreed with this item more than any other on the attitude survey.

While level of feedback influenced achievement and attitude in the current study, type of control did not. This could have been the result of

the CBI employed in this study. Control of practice may not have been enough for subjects to have felt in control of their learning. In fact, responses to the item, "I felt in charge of my learning" were neutral for subjects in all conditions.

It is also possible that type of control did not influence achievement and attitude because of the subjects who participated in the study. Subjects were junior high students who had little prior experience using a computer as the primary instructional delivery system. Hannafin (1984) stated that younger students and inexperienced students are not always able to function well under learner control because they are not always aware of what they need to know. Results for selection of optional practice support this notion. Subjects under learner control selected an average of two-thirds of all practice items. Only 20% of subjects given control selected all of the items.

The current study has some implications for instructional designers. CBI should include elaboration feedback, especially when students are asked to identify and label concepts such as parts of a microscope. This feedback should be designed to give students extra-instructional information to help them relate new information to their current knowledge base. This study also implies that CBI should not be designed to give correct-answer feedback only. When instructional technologists are limited by resources or cannot generate meaningful elaborations of content, it may be advisable to require students to review information to correct their mistake.

Future research should continue to explore the conditions under which feedback is most effective in computer-based instruction. Research should investigate how elaboration feedback influences student learning of different types of tasks. Perhaps elaboration feedback is most effective for teaching students how to label concepts such as learning parts of a microscope. Research should also examine the effect of different types of elaborations such as visualization cues. Implementation of these suggestions will help instructional technologists produce effective and efficient computer-based instruction.

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