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ABSTRACT

The primary purpose of this study was to examine the effects of replacing multiple-choice questions in tutorial software practice interactions with a learning strategy (i.e., learner-generated summaries) on immediate recall. Subjects were 35 students--32 females and 3 males--from an undergraduate computer course in the College of Education at Brigham Young University (Utah). The intervention for all treatment groups consisted of an interactive videodisk in developmental biology which had been developed using the traditional approach of instructional segment followed by multiple choice questions. Students were randomly assigned to three treatment groups and a pretest was administered. Students in Group 1 then answered multiple-choice questions after each of four instructional modules. In Group 2, students were asked to generate a written summary, which they typed in their own words on the computer, about the information presented in the module. Students in Group 3 were also asked to write a summary of the material just presented to them; however, after they wrote their summaries, they were provided feedback in the form of a system-generated summary of all of the main points in the module and told to compare the system-generated summary with their own. A posttest was administered and students were interviewed to determine whether they had used self-initiated learning strategies in addition to those designed in the interventions. It was found that replacing multiple-choice questions with learner-generated summaries not only did not facilitate immediate recall of the information presented, but reduced the efficiency of the learning process, since students who generated their own summaries took significantly longer to complete the instruction. (33 references) (BBM)

Title:

The Effects of Integrating a Learning Strategy in CBI

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The Effects of Integrating a Learning Strategy in CBI

Tutorial courseware allegedly enacts a dialog between the program designer and the learner. According to Soulier (1988), "dialog frames" present information to the learner, as well as carry out an interactive dialog/feedback between the learner and the computer. Soulier borrows the terminology of "dialog frames" from Alfred Bork (1980), who defined dialog as "a 'conversation' between a student and a teacher, where the student is at the computer display and the teacher is conducting the dialog through the medium of a computer program" (p. 15).

Soulier (1988) explains that dialog frames in computer-based instruction (CBI) usually have three parts: rules, examples and interactions. The information or subject matter is usually presented in the first two parts. The focus of this study is concerned with the third part, the practice component, or as Soulier refers to it, the interaction function.

According to Alessi and Trollip (1985), the most common method of CBI interaction is for the computer to pose questions the learner must answer. Questions serve a number of purposes. They keep the student attentive to the lesson, force the student to practice, and assess the student's recall and comprehension. In addition, student responses to the questions determine the sequencing for the remainder of the lesson.

Questions can be categorized into two basic types: selected-response and constructed-response. Selected-response questions are those for which the student chooses the correct response or responses from a list of two or more options. These include true/false, matching, multiple-choice, and marking. Multiple-choice items are the most common type of selected-response questions used in CBI (Alessi & Trollip, 1985). Constructed-response questions are open-ended questions that require the student to produce rather than select a response. The three major types of constructed-response questions are completion, short-answer, and essay. In CBI, the most common are completion and short-answer questions.

In a chapter of a recent book on designs for microcomputer courseware, Jonassen (1988) states that one of the problems with most tutorial courseware is that the level of mental processing required of learners is too shallow. He claims this weakness is due to the multiple-choice and short-answer questions predominantly used in CBI interactions. He states that the nature of the interactivity is usually recognition and recall of information presented on the previous screen, with little, if any, attempt to relate the information to prior knowledge, so that it will be meaningful and therefore retrievable by the learner. Jonassen (1988) states,

> Tutorial courseware is basically a mis-application of the programmed learning model of instructional design, which has been the dominant paradigm in the field of educational technology for nearly three decades. Since the programmed learning model is easily confused with the procedure or technique of programmed instruction, it is better conceptually defined by the mathemagenic hypothesis.
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> Mathemagenic behaviors are "those student activities that are relevant to the achievement of specified instructional objectives in specified situations or places," that is, those which "give birth to learning" (Rothkopf, cited in Jonassen, 1988). These behaviors, according to the hypothesis, can be controlled or manipulated by specific design attributes of instruction. The form or structure of instruction or the activities stimulated by it induce the necessary cognitive operations to produce the desired learning. . . . The purpose of mathemagenic activities, such as inserted questions (the basis of programmed learning), is to control the way in which information is transformed and encoded into memory. It is therefore a reductive approach to learning, which

> regards learners as active performers whose mental behavior should be strictly controlled by the activities imposed by the lesson. (p. 152)

Jonassen continues by stating that one of the problems with computer applications of the mathemagenic model is that the level of processing normally produced by mathemagenic behaviors (especially programmed learning) is too low or shallow.

To solve the problem, Jonassen (1988) recommends tutorial courseware be developed based on a more constructive conception of learning, that is, instruction which focuses more on cognition, requiring deeper levels of mental processing.

In order to increase the level of mental processing, Jonassen (1988) recommends that tutorial courseware should enhance meaning of course information by stimulating the learners to call up and apply what they already know. He suggests that this deeper processing can be achieved by incorporating learning strategies into the courseware. These learning strategies sometimes referred to as cognitive strategies, are mental operations or procedures that represent a wide range of cognitive activities including underlining main ideas, generating examples or analogies, summarizing, outlining, etc., which the student may use to acquire, retain, and retrieve different kinds of knowledge (Rigney, 1978). They are designed to increase the number of "links" between presented information and existing knowledge in order to enhance retention and to allow the student to process information generatively (Wittrock, 1974). They are always performed by the learner--at the initiation of the student or the instructional system.

According to Weinstein and Mayer (1986), in recent years increased attention has been placed on the role of the learner as an active participant in the teaching-learning act. Many articles suggest that the effects of instruction depend partly on prior knowledge, and the learner's active cognitive processing during the learning process (Anderson, Spiro & Montague, 1977; Cook & Mayer, 1983; Dansereau, 1985; Jones, Amiran & Katims, 1985; Mayer, 1984; Ryan, 1981; Weinstein, 1978; Weinstein & Underwood, 1985; Wittrock, 1974, 1978). Wittrock's (1974) generative learning hypothesis assumes that when faced with instructional stimuli, learners construct and assign meaning to the stimuli on the basis of prior learning. The meaning generated by learners for information they receive is individual and cannot be controlled by the author. According to Wittrock (cited in Jonassen, 1988), learning is not "a passive reception of someone else's organizations and abstractions" (p. 153). Instead, learning is an active, constructive process. Jonassen (1985) states,

> The purpose of generative strategies is to provide learners with active, constructive skills for proactively transferring prior knowledge. Meaning (knowledge, if you prefer) is learner-constructed, not media-controlled. These [learning] strategies, such as paraphrasing, generating questions, and imaging, are all individual processes for constructing meaning. (p. 31)

Jonassen (1985) explains that microcomputers are especially amenable to the inclusion of learning strategies because they can accept, store, and manipulate a variety of input, and they can insist on a response before allowing the learner to proceed; something which traditional print media cannot do. For instance, after presenting the information, the computer system could direct the learner to go through a particular learning strategy, with the computer functioning as an "electronic notebook." The learner can key in a response which the computer evaluates for quantity or existence of key concepts and sometimes manipulates through rearranging or mapping and then stores for use by learners as a review or retrieval strategy. Jonassen (1988) believes that assessing user input will ensure higher levels of processing than the multi-option recognition or recall tasks included in most tutorial courseware.

Jonassen (1988) recommends that "the simplest method for integrating [learning] strategies in courseware is to replace the adjunct, mathemagenic activities that are normally included as practice in courseware with specific information processing or perhaps metalearning strategies" (p. 160). More specifically he suggests:

> For example, rather than inserting multiple-choice questions to test immediate recall or comprehension of information in a program, you might periodically insert any of the following directions: Summarize in your own words the ideas presented; recall and record key ideas and use them to create analogies, outlines, or cognitive maps; draw a picture or generate a mental image of the subject matter; or list the implications of the material that you are studying. (p. 160)

In discussing the rationale for replacing multiple-choice and short-answer questions in CBI interaction frames, Jonassen (1988) explains that "only deeper, semantic processing of information requires the learner to access prior knowledge in order to interpret new material" (p. 153). He makes the point that integrating cognitive strategies into CBI interactions will facilitate higher level learning outcomes, such as comprehension and understanding, and will also increase the amount of information that is recalled. Because learners assign more meaning to the information presented during the tutorial, they will be able to remember more. Jonassen continues,

> It is exactly this level of meaningful learning that is most frequently missing from tutorial types of courseware. The emphasis is on practice of associations in working memory based only on information recently presented in the courseware. In interacting with the tutorial courseware, learners are too seldom required to access prior knowledge in order to interpret the information that is presented. (p. 153)

The primary purpose of this study was to examine the effects of replacing multiple-choice questions in tutorial courseware practice interactions with a learning strategy (learner-generated summaries) on immediate recall. The study was designed to investigate empirically the approach recommended by Jonassen (1988) to integrate learning strategies by replacing the traditional multiple-choice questions in CBI interactions.

Although several studies within the last few years have investigated the effects of integrating individual learning strategies in instructional systems and developing instructional systems that train learners how to use a particular learning strategy (Weinstein & Mayer, 1985; Dansereau et al., 1979; O'Neil, 1978; O'Neil & Spielberger, 1979), the practice of integrating learning strategies in CBI interactions has not received much attention in the research literature. The few studies which have been conducted had a different focus than the present study. For example, these studies either dealt with a different learning outcome than immediate recall or the study tried to validate a different type of learning strategy (for example, see Eucker, 1984; Allen, 1982; Wilshire, 1990). The findings from these studies did not support the hypothesis that integrating a learning strategy in CBI would be more effective in facilitating learning than the traditional approach used by the comparison group(s).

Several studies have examined different aspects of student-generated summaries (Annis, 1985; Brown, Campione, & Day, 1981; Day, cited in Brown, Campione, & Day, 1981; Ballesteros, 1986); however, none have examined the specific effects of integrating this strategy in CBI interactions on immediate recall.

The following hypotheses and research questions were addressed in this study:

Hypotheses

1. Learner-generated summaries in tutorial courseware will be more effective in facilitating learners' ability to immediately recall information than multiple-choice interactions.
2. A system-generated summary provided to learners (as a form of feedback) after they generate their own summaries will be more effective in facilitating learners' ability to immediately recall information than not providing a system-generated summary.

Research Questions

1. Will students who are required to generate summaries take significantly more time to complete the intervention than students who respond to multiple-choice interactions?
2. Will students who are provided a system-generated summary type fewer words in their summaries than students who are not provided a system-generated summary?
3. Will typing rather than writing the learner-generated summaries affect the quantity or quality of the summaries?
4. To what degree will students use self-initiated learning strategies during the intervention?

Method

Subjects

Subjects were obtained from an undergraduate computer course (Computers in Education) offered in the College of Education at Brigham Young University in Provo, Utah. They were required to complete the intervention for this study as one of their assignments in the course. Thirty-five students participated in the study: thirty-two females and three males.

Materials

The intervention for all treatment groups consisted of an interactive videodisc tutorial on the subject matter of developmental biology, developed by WICAT Incorporated in 1979, under a grant from the National Science Foundation (Bunderson, Olsen & Baillio, 1981). The hardware consisted of a Macintosh-based interactive videodisc system.

The instruction, which was developed for university-level students, dealt primarily with verbal information learning outcomes. This explanative material (Mayer, 1989) consisted of an introduction to basic developmental biology concepts such as DNA, RNA, genes, chromosomes, etc. It was selected for several reasons. First, the researcher believed that most students had very little prior knowledge about the content, which was desirable in determining whether a learning effect occurred as a result of the treatment. Second, the instruction on the videodisc had been developed using the traditional type of CBI interactions: an instructional segment followed by multiple-choice questions. Finally, since the content area was not related to the course in which students were enrolled, the researcher believed the students would not make extensive use of self-initiated learning strategies as they completed the instruction.

The interaction frames and the courseware that controlled the videodisc were developed on the computer by use of the authoring program *The Best of Course of Action*, developed by Authorware, Incorporated (Authorware, 1987).

Research Design

The research was conducted using a Pretest-Posttest Comparison Group Design. The students were randomly assigned to one of three treatment groups. The instruction delivered during the intervention was the same for all three treatment groups--four modules consisting of videodisc motion sequences and several still frames concerning developmental biology. Students in Group 1 answered multiple-choice questions after each instructional module. In Group 2, students were asked to generate a written summary, which they typed in their own words on the computer, about the information presented in each module. Students in Group 3 were also asked to type a written summary of the information just presented to them; however, after they wrote their summary, they were provided feedback in the form of a system-generated summary which summarized all of the main points in the module and were told to compare the system-generated summary with their own to determine if they had left out any important ideas.

The independent variable was the type of learner response required during the CBI interaction following the instructional modules. The dependent variable for the hypotheses was the posttest score.

Instruments

A pretest was developed to assess the preexisting knowledge of students on the content of developmental biology in order to determine if the three treatment groups were equivalent as a result of random assignment to groups. A posttest was developed using items selected from a posttest developed by WICAT Inc., based on the information presented in the videodisc. The test consisted of multiple-choice, matching, true/false, and short-answer test items which assessed recall learning outcomes.

Internal consistency reliability measures were computed on the test scores to assess the reliability of the results. The reliability (Cronbach Alpha) coefficients for the pretest and posttest scores were .76 and .72, respectively.

Procedure

The researcher administered the intervention for each student individually during a one-hour time slot. When the student arrived, the researcher briefly explained the nature of the study and then requested him or her to sign a participation consent form and complete the pretest. The researcher then gave the student a brief overview on how to use the instructional system.

After the orientation, the students were presented a module of instruction consisting of several still frames and a motion sequence. The students were then asked to either answer multiple-choice questions or generate a summary of the information just presented. Students in Group 1 who selected the correct answer were given a short statement affirming the correct selection. Students who selected the wrong answer were told their answer was incorrect and then given the correct answer. Students in Group 2 were asked to generate a summary of the material just presented. After the student typed his or her summary, the instructional system presented the next module. Students in Group 3 were given the same instructions as those in Group 2; however, immediately after the students typed their summary, the system presented a complete summary of all the main ideas presented as a form of feedback. Students were asked to compare their summaries to the system-generated summary to determine if they had left out any important information or concepts. This pattern continued for the remaining three modules. Students in Group 1 answered a total of 20 multiple-choice practice items, and students in Groups 2 and 3 generated four summaries during the entire intervention.

After the students completed the intervention, they took the posttest. Students took an average of 60 minutes to complete the entire process.

Data Analysis

The hypotheses were analyzed using a planned, orthogonal comparison statistical design. Information related to the first two research questions (minutes of elapsed time and average number of words written in the learner-generated summaries groups) was analyzed for the three treatment groups using one-way analysis of variance. The last two research questions were analyzed using descriptive statistics.

Results

Of the 35 subjects, 12 were in Group 1, which answered multiple-choice questions, 11 were in Group 2 which generated summaries without feedback, and 12 were in Group 3 which generated summaries and received feedback. Means, standard deviations, and ranges were computed on (a) the number of correct answers on the pretest (20 points possible), (b) number of correct answers on the posttest (33 points possible), (c) instructional time, and (d) number of words in student-generated summaries (for Groups 2 and 3 only). Table 1 summarizes these computations.

Table 1

Group Means, Standard Deviations, and Ranges for Pretest Scores, Posttest Scores, Instructional Time, and Number of Words in Student-Generated Summaries

Treatment Group	Pretest Scores	Posttest Scores	Instructional Time (minutes)	Number of Words in Summaries
Group 1 (Multiple-choice items)				
Mean	8.3	24.3	25.0	NA
SD	3.1	2.5	5.1	NA
Range	2-12	18-28	19-33	NA
Group 2 (Student-generated summaries without feedback)				
Mean	8.2	23.2	35.6	205.0
SD	4.6	3.7	12.0	74.2
Range	1-14	17-28	20-64	87-344
Group 3 (Student-generated summaries with feedback)				
Mean	8.9	24.0	34.9	236.2
SD	4.2	4.1	8.5	116.6
Range	2-15	16-30	17-53	77-504

One-way analysis of variance revealed that the differences between means on the pretest scores were not statistically significant, indicating that the three groups were equivalent in preexisting knowledge about the material presented in the instruction, $F(2, 32) = .11$, $p = .896$.

The first hypothesis (learner-generated summaries groups will score higher than the multiple-choice group) was tested using a complex, orthogonal, planned comparison analysis (Keppel & Zedeck, 1989), in which the average of the means for the two learner-generated summaries groups (Groups 2 & 3) was compared with the mean of the multiple-choice practice group (Group 1). Results from the analysis indicated no significant treatment effects, $T(32) = .53$, $p = .60$.

The second hypothesis (Group 3 will score higher than Group 2) was tested using a pairwise, orthogonal, planned comparison analysis, in which the mean of the learner-generated summaries without feedback group (Group 2) was compared with the mean of the learner-generated summaries with feedback group (Group 3). Results from the analysis indicated no significant differences between the two groups, $T(32) = .57$, $p = .58$.

With regard to the question of instructional time, Table 1 shows that students in Group 1 spent an average of 10 minutes less than students in Groups 2 and 3 during the instruction. One-way analysis of variance resulted in a significant difference between the means of the treatment groups, $F(2,32) = 5.3$, $p = .01$. Results of a Tukey-HSD post hoc comparison analysis ($p < .05$) indicated that Groups 2 and 3 differed significantly from Group 1.

The second research question sought to determine if there was a significant difference in the number of words generated by the students in Group 2 and Group 3, based on the concern that students in Group 3 might minimize the words they wrote in their self-generated summaries as a result of knowing they would be presented a system-generated summary after typing in their summary. Table 1 shows that Group 3 generated an average of 30 more words than students in Group 2. A one-way analysis of variance showed that the difference between means was not statistically significant, $F(1, 21) = .572$, $p = .458$.

The third research question examined whether typing rather than writing affected the quality of the students' summaries. To answer this question, the researcher asked students who generated their own summaries if they felt typing versus writing their summaries affected the quality and quantity of those summaries. Of the 23 students who responded, three students indicated that they would have written more and their summaries might have been of a higher quality had they been allowed to write the summaries on a piece of paper. All other students indicated that typing was not a factor in generating their summaries. Twenty students said they would prefer to type their summaries if given a choice, whereas three students indicated they would prefer to write their summaries.

The fourth research question was critical to the final study: If students used extensive self-initiated learning strategies in addition to those designed in the interventions, the results would perhaps be influenced more by learner variance than by treatment variance. The students were interviewed and asked what self-initiated learning strategies, if any, they used as they progressed through the instruction. The results as summarized in Table 2, show that 66 percent of the students used rehearsal strategies which consist of repeating more than once in their minds the material presented to them. However, as Table 2 shows, few students used any learning strategies other than the rehearsal technique strategies.

Table 2

Self-initiated Learning Strategies Used by Students

Response Categories	Number of Respondents	Percentage of Respondents
Rehearsal	23	66%
Organizational Strategy	8	23%
Mnemonics	7	20%
Mental Imagery	3	9%
Note Taking	2	6%

Note: These percentages do not add up to 100 percent because students could give more than one response.

Discussion

The results of this study did not support the first hypothesis: replacing multiple-choice questions with learner-generated summaries in tutorial courseware did not result in learners recalling significantly more of the information presented during the instruction. In addition, the results show that students in the learner-generated summary groups took significantly more time to complete the intervention than students in the multiple-choice questions group.

It was also hypothesized that providing a system-generated summary to learners after they generated their own summary would be more effective in facilitating learners' ability to immediately recall information than not providing a system-generated summary. The results did not support this hypothesis.

What are some of the theoretical implications of these findings? First, because of the small number of subjects in each group, learner variance could have had a significant influence on the results. The researcher plans to continue this line of research with a larger sample size. Second, for the particular recall learning outcome assessed in this study, students may need the practice items of multiple-choice questions to provide the necessary repetition required for immediate recall (Gagne, 1985; Gagne, Briggs & Wager, 1988). Third, the multiple-choice response items may have highlighted the key knowledge elements presented in the instruction which focused the learners' attention on the information that was really important. Fourth, another theoretical issue which may have had some influence on the results of this study is the degree of instructional alignment between the learning strategy and the learning outcomes (Cohen, 1987). Perhaps using learner-generated summaries was not the most appropriate strategy to use for the particular learning outcome measured. Learner-generated summaries may have facilitated other higher-level learning outcomes that were not measured in this study, such as understanding, transfer, synthesis, etc. Finally, another possible explanation which may have influenced the results of this study was the degree to which students wrote effective summaries. Perhaps the subjects in this study were much more familiar with responding to short-answer and multiple-choice items and hadn't received much practice in writing summaries.

The results of this study show that replacing multiple-choice questions in tutorial courseware with learner-generated summaries does not facilitate the specific learning outcome of immediate recall for the specific material used in this study. In fact, replacing multiple-choice questions with learner-generated summaries in CBI interactions reduced the efficiency of the learning process, since students who generated their own summaries took significantly longer to complete the instruction.

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