The Effect of Interaction and Perceived Need for Training on Learning and Time Spent Learning from Computer-Based Instruction

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Abstract: Commonly, computer-based Instruction (CBI) Is designed to expose learners to a series of instructional frames, followed periodically by inserted questions to reinforce learning. The practice is so widespread that the efficacy of such an approach is seldom questioned. This study examined whether covert or overt strategies were effective and efficient methods of stimulating interaction in CBI, and whether the effectiveness and efficiency of embedded strategies are modified by the perceived need for training of learners. Results indicated that learners with high perceived need for training found embedded questions which required structured overt responses to be more effective and efficient than competing treatments. Learners with low perceived need for training, however, achieved similar amounts of learning from all treatments offered, but found a treatment without embedded strategies (questions or review frames) to be the most efficient treatment offered.

An ample and growing body of evidence supports the use of computer assisted instruction as a technology of instruction. CBI applications compare favorably to other methods of instruction across a variety of subjects, modes, and grade levels on measures of learning and time (Edwards, Norton, Taylor, Weiss & Dusseldorp, 1975; Kulik, Bangert & Williams, 1983; Kulik, Kulik & Cohen, 1980). That CBI can be effective is interesting, per se, but it also begs the question "why?" Clark (1985) has argued that achievement gains often found in CBI studies may, in fact, be attributable to "uncontrolled but robust methods embedded in CBI treatments" (p. 249). In other words, CBI's observed effectiveness may be more a product of the care that went into the design of the instruction than of the medium itself. At the same time, the call has been out for some time now for research that investigates the unique contribution made to learning effectiveness by the interaction of learner and communication medium variables (e.g., see Clark, 1983). Restated, what design and learner variables interact with the medium to promote or inhibit its effectiveness?

Learner Interaction

From the time of research into programmed instruction in the 1960's, requiring the learner to respond meaningfully to the instruction has been

CJEC, VOL. 17, NO. 3, PAGES 147 -158, ISSN 0710-4340

accepted in both theory and practice. Effective learners actively interact mentally during instruction, suggesting that both attention and manipulation of information can improve information acquisition and retrieval (Bransford, 1979; Dwyer & Dwyer, 1987), and instructional designers are exhorted to provide for meaningful interaction in order to produce effective instruction (e.g., see Markle, 1978). Providing the learner with opportunities to rehearse or practice using information likely stimulates the attention and manipulation activities desired. Meaningful rehearsal also increases the likelihood that information will be transferred from short-term to long-term memory (Dwyer & Dwyer, 1987).[1]

A variety of interventions have been suggested to accomplish covert and overt learner interaction with instruction. Researchers searching for robust methods for stimulating interaction have employed devices such as adjunct questions (Dayton & Schwier, 1979), mnemonic devices (Atkinson, 1975), images and verbal contextual organizers (Bernard, Petersen & Ally, 1981), and illustrations (Duchastel, 1980). At the heart of most studies is the notion of learner activity or interaction. Rothkopf (1970) used the term "mathemagenic" to refer to those activities of the learner which produce learning. Thus, mathemagenic activities mediate the nominal stimulus (the stimulus as presented) and the functional stimulus (the stimulus as perceived by the learner) to shape learning (Underwood, 1963). It can be expected, on these bases, that with CBI, requiring learner interaction should lead to greater learning.

Overt and Covert Activity

In experiments, overt activities such as test-like events are often used because of the difficulty of measuring the amount or quality of mental activity devoted to instruction covertly. A motivated learner may impose aggressive mental activity on instruction, such as developing analogies, creating mnemonic devices, mentally practicing material, and testing personal assumptions. Certainly, this type of covert mathemagenic activity may result in increased learning. Another learner may adopt a passive posture, casually drift through instruction, and exhibit poorer performance. The differing quality of activity is difficult to measure, and usually remains unseen by the researcher.

On the other hand, overt activities can be observed, and may force attention to and interaction with information. Learners who are otherwise passive can be challenged to examine their understanding and modify their approaches to instruction. This assumes a modest level of coercion; the learner must interact with instruction regardless of the need for interaction. Perhaps it can be assumed that such intervention will help most students, and will serve as a placebo reinforcement for others who are covertly active. But, is it

[1] This discussion refers to the literature on levels of processing, an established concept in cognitive psychology. The reader may wish to refer to Craik and Lockhart (1972) and Craik and Watkins (1973) for elaboration.

possible that this organized imposition could interfere with covert strategies that motivated learners already bring to instruction? For example, will a learner who covertly develops an analogy to explain a particular construct find an externally imposed analogy distracting?

Computer based instruction offers developers a wide range of opportunities to impose covert and overt mathemagenic strategies on learners. Theoretical explanations for mathemagenic behaviours include learner-active constructs such as forward shaping and internal processing (Boyd, 1973; McConkie, Rayner & Wilson, 1973), and learner-passive constructs such as additional review or exposure to instruction (McGaw & Grotelueschen, 1972; Rickards & DiVesta, 1974; Yost, Avila & Vexler, 1977). Most studies have ignored these competing explanations for increased learning. One purpose of this study, therefore, was to examine whether an overt strategy, in this case embedded questions, facilitates learning to a greater extent than a covert strategy, in the form of review or summary frames which provides redundant information. In other words, if additional learning occurs with CBI which contains mathemagenic strategies, is it the result of additional exposure to content, or can it be explained by the active role of the learner in the instructional process?

Given the above discussion on the reputed importance of interactivity in fostering learning and the potentially different quality of overt versus covert strategies, it is reasonable to hypothesize that embedded questions (being overt and requiring interaction) will produce more learning than will covert strategies. Further, since review frames can be viewed as offering opportunities for (but not requiring) additional cognitive processing, it may be hypothesized that the inclusion of review frames will allow for greater reflection, and therefore learning, than CBI without such frames.

Perceived Need for Training

Given the vast literature showing the effects of motivation on learning, we speculate that different learners might naturally invest differently in the instruction, based upon their motivation to acquire the knowledge. In other words, as learners' perceptions of their need to learn vary, so might the amount of covert activity brought to bear on the instruction. Schwier (1986) speculated that learners' perceived need for training could interact with different instructional treatments to influence learning outcomes. A trivariate model of instructional need proposed by Misanchuk (1984a) was used in this study to determine the learners' perceived need for training. The model suggests that instructional need, under various circumstances, could be viewed as a function of the learners' perception of the relevance (R) of the instruction, the individual's extant competence (C) in the task or skill to be taught, and the desire (D) to take training on the subject.

Learning Time

CBI typically relinquishes control of time spent on instruction to the learner, and functionally, a learner could dramatically influence the amount of

time spent on instruction. Embedded questions or review frames interspersed throughout instruction might also serve to increase the total amount of time a particular learner spends on instruction. Does the increased time required to respond to questions or read review frames produce sufficient additional learning to justify the additional time devoted to instruction? Perhaps more is learned, but at the expense of time which could be devoted to other learning Opportunities. Dayton and Schwier (1979) found that exposure to adjunct questions impaired incidental learning efficiency. Their findings were related only to fixed-pace, fixed-sequence media, however, and cannot necessarily be generalized to CBI, which allows a greater degree of learner control. We speculate that an interactive medium which permits a high degree of learner control may also introduce the possibility of an increase in learning time.

HYPOTHESES

1) Performance on learning measures will reveal a hierarchical relationship among treatments such that CBI with questions will be superior to CBI with review frames, and both will be superior to the control group receiving just CBI.

2) Learners with high perceived need for training will exhibit superior performance on learning measures than will learners with low perceived need for training.

METHODOLOGY

Treatments

Three parallel content versions of experimental and control treatments were developed, employing approximately four hours of computer-based training on the topic of financial management for supermarket managers. The instruction introduced learners to the terminology of financial management, and how to analyze and interpret a charge gross report and store operating statement. Content and examples specifically referred to the financial operation of the corporation which employed the *high need* group subjects, but dealt with concepts which had general application in business finance. Experimental treatment #1 (CBI + Q) included embedded post-questions inserted throughout the instruction,[2] and feedback to the learner's response to the question. Experimental treatment #2 (CBI + R) included review frames which summarized or reiterated the content treated by the embedded post-questions in the CBI + Q treatment. A control treatment (CBI) was developed which

[2]The questions were of the type that might serve as review questions following a segment of instruction, but were actually inserted in various locations close to, but following, their referents.

contained the same content but neither embedded post-questions nor review frames.

Experimental and control treatments contained identical menu and instructional structures, save the question and review frames offered in the experimental treatments. In all treatments, the subject determined the order and amount of time spent on various components of instruction.

All treatments were compatible with MS-DOS based microcomputers, and were primarily textual with modest graphics. Although the instruction was designed to be used with either colour or monochrome systems, all subjects received the treatment on monochrome displays. Typically, subjects required approximately four hours to complete the instruction, although time on task varied considerably among subjects.

Subjects

High-need subjects (n = 18) were recruited from among assistant managers and department managers for a large food store chain in the southeastern United States. As a check on the assumption that these subjects had high need for training, each subject completed a needs assessment instrument. It was suspected that job role might influence scores, so each group was matched according to job role (assistant managers, department managers). Beyond this, assignment to treatments was random.

Low-need subjects (re = 18) were recruited from a management training course at the University of Saskatchewan, under the assumption that subjects not employed in supermarket management would exhibit significantly lower perceived need for training than those in the high-need group. The same needs assessment instrument was administered to test this assumption.

Measures

Needs data were collected using a questionnaire which asked subjects to rate the perceived relevance (How relevant is this item to someone who does your job?), competence (How knowledgeable or skilled are you in this item?) and desire (How motivated are you to undertake training on this item?) of the ten major topics in the CBI program *(see Figure 1 on following page).* Average scores for each of relevance, competence and desire were computed for the high-need and low-need groups *(See Table 1 on next page).*

The measure of learning consisted of sixty knowledge and application level items constructed from the objectives for the instruction. All of the items were novel; they did not appear as embedded questions in the CBI + Q treatment. Twenty questions were administered to subjects following their completion of each of the three units of instruction. Fifteen items were presented on the computer and five were written on an accompanying handout. It was discovered only after the first group was tested that the program stored only total scores and not item scores, so an estimate of the reliability of the measure could not be made.

The total instructional time was recorded by subjects following each unit. This was monitored by a research assistant, to ensure that time was faithfully registered by subjects during instruction.

Figure 1. ***Sample*** *of Training Needs Questionnaire.*

COMPUTER-BASED TRAINING FIELD TEST NEEDS ASSESSMENT

Instructions: A list of items appears below concerning financial management in retail groceries. Rate each item in terms of its **Relevance** to someone in your position, your **Competence** in performing that item, **Desire** to take training on that item. **Circle the numbers which are appropriate, and fill out the form completely.**

	Relevance How relevant is this item to someone who does your job? 1. Highly relevant 2. Relevant 3. Useful, but not important 4. Not very useful 5. Irrelevant	***Competence*** How knowledgeable or skilled are you in this item? 1. Highly competent 2. Competent 3. Somewhat competent 4. Not very competent 5. No competence	***Desire*** How motivated are you to undertake training on this item? 1. Highly motivated 2. Motivated 3. Somewhat motivated 4. Ambivalent 5. Would rather not participate
1. Basic financial management terms and definitions	*1 2 3 4 5*	1 2 3 4 5	1 2 3 4 5
2. Major principles of financial management	*1 2 3 4 5*	1 2 3 4 5	1 2 3 4 5
3. Familiarization with financial management documents	*1 2 3 4 5*	1 2 3 4 5	1 2 3 4 5
4. Basic business mathematics	*1 2 3 4 5*	1 2 3 4 5	1 2 3 4 5
5. Terms and definitions on the Charge Gross Report	*1 2 3 4 5*	1 2 3 4 5	1 2 3 4 5

Procedure

Subjects were first asked to complete the needs questionnaire, after which they were assigned to a computer, and given instructions on how to record scores and time for each unit. Each was first exposed to an introductory unit which introduced the CBI program, and was given the information needed to use the microcomputer. This permitted a standardized set of instructions and also accommodated settling behaviours.

Each subject then completed the CBI individually; the research assistant ensured that the same protocol was followed by all subjects.

Experimental Design and Analysis

The design employed was a 2 x 3 factorial analysis of variance. The independent variables were perceived need for training (high.low) and treatment (CBI + Q, CBI + R, CBI). The assumption regarding the classification of perceived need for training was checked by performing £-tests on the average scores for both need groups for each of the relevance, competence, and desire scales.

As is almost customary in CBI studies, the dependent variables were achievement (as measured by an achievement test) and time to complete instruction.

RESULTS

Check on Assumptions Regarding Need for Training

The data confirmed the assumption that the high-need subjects did in fact have a higher perceived need for training, in terms of two of the three components of the RCD model, than did the low-need subjects. Mean scores for the two groups on the three components are shown in Table 1. One-tailed t-tests showed that all three differences are significant.

For complete fidelity to the RCD model, the high-need group would have

TABLE 1
Average Scores for Relevance, Competence, and Desire for High-Need and Low-Need Subjects

	Average Scores		
Component of Need	Low Need	High Need	
Relevance	3.23	1.50	- 5.98*
Competencet	3.64	2.51	- 4.28*
Desire	2.83	1.60	- 4.42*

*p < 0.0001, one-tailed test

t Scale descriptors are such that a high score indicates low competence.

needed to demonstrate equal or inferior competence in comparison to the low-need group, yet they did the opposite. In light of the reality of the experiment, this should not be surprising, since the subjects in the high-need group were already in job roles that used many concepts and procedures similar to the ones that were being taught in the instructional treatment.

Inasmuch as a) the RCD model was employed only to check an assumption, b) the three components of need for training are normally weighted as equally important (Misanchuk, 1984b), and c) two of the three components of the model matched the direction predicted by the model, with the deviant one being the weakest of the three (in terms of magnitude of *t),* the assumption of differences between the two groups with respect to need for training was deemed confirmed.

The data related to learning performance were subjected to two-way analyses of variance, using achievement and time, in turn, as dependent variables.

Achievement

With achievement as the dependent variable, the analysis of variance showed that neither perceived need for training nor question treatment had a significant effect (see Table 2). However, there was a significant effect for the interaction of the two variables *(F* = 5.08, *p* = .013).

TABLE 2
Analysis of Variance with Achievement as the Dependent Variable

Source	*df*	*SS*	*MS*	*F*	*p*
Motivation (A)	1	13.44	13.44	.24	.62
Treatment (B)	2	276.17	138.08	2.54	.10
A x B	2	552.06	276.03	5.08	.01
Error	30	1629.33	54.31		

Inspection of the cell means (see Table 3 next page) showed that the high-need group under the inserted questions treatment condition had substantially higher achievement than learners under other conditions. A Newman-Keuls test revealed that the mean for the high need/inserted questions condition was significantly higher than all other means *(p* < .01). In addition, the low need/control condition mean was significantly higher than the high need/control treatment condition mean (p < .01).

Time

With time as the dependent variable, the analysis of variance showed no significant effects *(F* < 1.0) (see Table 4).

TABLE 3
Means of Cells with Achievement as the Dependent Variable

	Treatment		
Need for Training	CBI + Q	CBI + R	CBI
High	51.7	39.2	36.5
Low	39.8	40.5	43.3

DISCUSSION

The results of this study led to the rejection of hypotheses 1 and 2, but revealed an interesting interaction between perceived need for training and treatments. These results support the notion that inserting questions periodically within CBI can increase achievement for individuals who have a high degree of perceived need for the knowledge and skills. The same did not hold true for individuals with lower levels of perceived need for training. For low-need individuals, these data would suggest that no embedded strategy is superior to another to enhance achievement.

TABLE 4
Analysis of Variance with Time as the Dependent Variable

Source	*df*	SS	*MS*	F	*P*
Motivation (A)	1	2070.25	2070.25	1.11	.30
Treatment (B)	2	10348.67	5174.33	2.79	.08
A x B	2	2660.67	1330.33	.72	.50
Error	30	55727.17	1857.57		

What light do these results shed on the controversy surrounding the use of embedded strategies in CBI? Since the amount of time taken to complete the instruction is not significantly different under any treatment condition, we can focus our attention solely on achievement. Embedded questions appear to offer advantages to learners with high perceived need for training and do not

disadvantage learners with low perceived need for training. Perhaps learners with higher perceived need for training interact more aggressively with the questions, resulting in more cognitive activity and therefore a greater depth-of-processing.

One interesting finding was that the time-on-task for the control treatment did not differ significantly from the time-on-task for treatments with embedded questions or review frames, even though the control treatment had fewer frames. We offer two possible explanations that are speculative. First, individuals receiving the control treatment (no interaction) may have become bored and sluggish in response to the page-turning approach, and thus moved more slowly through the instruction. Second, it is possible that individuals introduced their own cognitive strategies to the instruction when they were not provided. These self-imposed strategies may have occupied as much time as reviewframes or embedded questions. We have no data to suggest a preference for either the "learner-active" or "learner-sedated" explanation, but we suggest that such a question deserves study.

More difficult to explain is the anomaly of the low-need learners performing significantly better than the high-need learners under the control treatment, and we present the finding merely as an observation.

Overall, the data suggested that the level of perceived need for training may be an influential mediator in CBI. Subjects in the high-need group experienced instruction which was specifically designed for their jobs, and the match between the content of instruction and perceived need for training may have influenced subjects' willingness to invest actively in structured opportunities for practice. The job-specificity of the content allowed the researchers to identify groups with different levels of perceived need for training. We are not able to comment on whether these results can be generalized to groups which have "closer" levels of perceived need for training, as is often found in traditional classrooms or training events. Future studies, however, might fruitfully examine a continuum of need levels to determine how sensitive achievement and efficiency of CBI treatments are to a continuum of perceived need for training.

REFERENCES

Atkinson, R. (1975). Mnemotechnics in second-language learning. *American Psychologist, 30,* 821-828.

Bernard, R.M., Petersen, C.H., & Ally, M. (1981). Can images provide contextual support for prose? *Educational Communication and Technology Journal,* 29(2), 101-108.

Boyd, W.M. (1973). Repeating questions in prose learning. *Journal of Educational Psychology, 64,* 31-38.

Bransford, J. (1979). *Human cognition: Learning, understanding, and remembering.* Belmont, CA: Wadsworth Publishing.

Clark, R. (1983). Reconsidering research on learning from media. *Review of Educational Research,* 53(4), 445-459.

Clark, R. (1985). Evidence for confounding in computer-based instruction studies: Analyzing the meta-analyses. *Educational Communication and Technology Journal,* 33(4), 249-262.

Craik, R, & Lockhart, R. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11,* 671-684.

Craik, R, & Watkins, M. (1973). The role of rehearsal in short-term memory. *Journal of Verbal Learning and Verbal Behavior, 12,* 599-607.

Dayton, D., & Schwier, R. (1979). The effect of inserted questions and individual differences on learning from fixed-pace, fixed- sequence media. *Educational Communication and Technology Journal, 27(2),* 103-113.

Duchastel, P. C. (1980). Research on illustrations in text: Issues and perspectives. *Educational Communication and Technology Journal, 28(4),* 283-287.

Dwyer, R, & Dwyer, C. (1987). *The effect of time as an instructional variable on students' ability to profit from visualized instruction.* Paper presented at the annual conference of the Association for Educational Communications and Technology, Atlanta, GA.

Edwards, J., Norton, S., Taylor, S., Weiss, M., & Dusseldorp, R. (1975). How effective is CAI? A review of the research. *Educational Leadership,* 33(2), 147-151.

Kulik, J., Bangert, R., & Williams, G. (1983). Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology, 75(1),* 19-26.

Kulik, J., Kulik, C., & Cohen, P. (1980). Effectiveness of computer-based college teaching: A meta-analysis of findings. *Review of Educational Research, 50(4),* 525-544.

Markle, S. *(1978). Designs for Instructional Designers.* Champaign, IL: Stipes Publishing.

McConkie, G. W., Rayner, K., & Wilson, S. (1973). Experimental manipulation of reading strategies. *Journal of Educational Psychology, 65,*1-8.

McGaw, B., & Grotelueschen, A. (1972). Direction of the effect of questions in prose material. *Journal of Educational Psychology, 63,* 580-588.

Misanchuk, E. R. (1984a). Analysis of multi-component educational and training needs. *Journal of Instructional Development,* 7(1), 28-33.

Misanchuk, E. R. (1984b). *The analysis of multi-component educational and training needs: The multivariate case.* Paper presented at the annual meeting of the Association of Educational Communications and Technology, Dallas, TX.

Rickards, J. P., & DiVesta, R J. (1974). Type and frequency of questions in processing textual material. *Journal of Educational Psychology, 66,* 354-362.

Rothkopf, E. (1970). The concept of mathemagenic activities. *Review of Educational Research, 40,* 325-336.

Schwier.R.A.(1986).Applyingneedstoinstructionaldevelopment:Extension of the R-C-D Model. *Canadian Journal of Educational Communication, 15(2),* 91-104.

Underwood, B. J. (1963). Stimulus selection in verbal learning. In C.N. Gofer & B.S. Musgrave *(Eds.).Verbal behavior and learning.* New York: McGraw-Hill.

Yost, M., Avila, L., & Vexler, E. (1977). Effect on learning of post-instructional responses to questions of differing degrees of complexity. *Journal of Educational Psychology, 69,* 399-408.

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