PROCESSING ATTENTION AND QUESTION DENSITY IN COMPUTER-BASED INSTRUCTION

By: William A. Kealy and Howard J. Sullivan

Kealy, W. A., & Sullivan, H. S. (1991). Processing attention and question density in computer-based instruction. *British Journal of Educational Psychology, 61*, 230-232.

Abstract:
The effect of density of embedded post-questions on learning from computer-based instruction (CBI) was studied among 90 sixth-graders randomly assigned to three versions of a CBI programme — high density, low density, and no embedded questions. Children made significant achievement gains across each increase in question density, consistent across the continuum of reading ability represented in the study. High question density facilitates student learning from embedded post-questions in CBI and does not appear to seriously diffuse processing attention.

Article:

INTRODUCTION

The value of adjunct post-questions in facilitating learning from text is well established (e.g., Rothkopf, 1966; Anderson and Biddle, 1975). A recent explanation for this effect is that learners approach a reading task with a set amount of processing attention and that post-questions enable them to selectively allocate the attention to the most relevant parts of the text (Anderson, 1982; Kulhavy *et al.*, 1986).

The Anderson and Kulhavy *et al.* position raises important questions for the rapidly growing computer-based instruction (CBI) field. CBI programmes in the schools employ embedded questions much more commonly than paper-based instructional programmes. However, the frequency and number of questions varies widely from programme to programme (Schloss *et* al., 1986). Does high density of questions improve learner achievement by increasing the breadth of focus for processing attention and the amount of relevant practice? Or, conversely, does high question density create an excessively strong processing demand that diffuses attention and consequently inhibits student learning?

Another issue related to post-questions has to do with their effects across reading levels. Seretny and Dean (1986) found a significant effect for embedded post-questions on the reading comprehension of sixth graders who were below-average and average readers, but not for above-average readers. They suggest, however, that the non-significant results for high readers may be due to a ceiling effect on their criterion measure. An alternative explanation, of course, is that capable readers already possess superior processing skills and therefore benefit less from embedded post-questions.

The present study was conducted to investigate the effects of question density — the number of embedded post-questions per question set — on student learning from computer-based instruction. Post-test scores were also analysed by reading ability to determine the consistency of effect for post-questions across reading levels.

METHOD

Design and sample

The study incorporated a randomised post-test only control group design with two experimental groups and with the no-question treatment serving as the control group.

Participants in the study were 90 sixth-grade students, 30 per treatment, from two suburban elementary schools in Phoenix, Arizona. AB students had prior experience using microcomputers.

Materials

Text passage. The basic instructional material for the study was a 912-word text from the Grade 5-6 "Power Switch" unit of the Energy Source Program (Energy Source Educational Council, 1984), a nationally distributed energy education programme used by approximately a million students a year. The text describes potential alternative energy sources such as wind power, synthetic fuels and nuclear fusion.

Computer programmes. The text was adapted for computer presentation using the Super PILOT authoring language. Three versions of the CBI programme were then created, each with a different level of question density. In the high-density version, a set of six questions was inserted after each of four text passages of approximately 230 words per passage. The low-density version had a set of three questions each in the same four text locations. Thus, the high-density version had 24 questions in all and the low-density version had 12 questions. The no-question version contained the text only without embedded questions.

The questions were short-answer recall items covering content from the preceding passage. The high-density version averaged one question per 38 words of text and the low-density version one question per 76 words.

Tests

Text recall was measured using a 24-item post-test covering the same content as the embedded post-questions. The test was developed in constructed-response format to minimise the possibility of high achievement and a ceiling effect such as reported by Seretny and Dean (1986). The KR-21 reliability coefficient for the post-test, calculated on the 90 subjects from this study, was 0.85.

Completion times for each child on both the reading the post-test activities were measured by the computer programme.

Reading ability of children in the study was determined by obtaining their raw scores on the Iowa Reading Achievement Test that had been administered during the previous year.

Procedure

Computer diskettes, representing equal numbers of the three lesson versions, were shuffled and randomly distributed among the 12 microcomputers in the school computer laboratory. Children participated in groups of 12 and were randomly assigned to the microcomputers as they arrived for the study. This procedure resulted in a total of 30 students per treatment. Students progressed at their own pace through their assigned programme without knowledge of the differing versions, then completed the post-test. After the post-test, the computer branched children to a second instructional programme for the remainder of the class period.

RESULTS

Regression analysis of post-test scores on Iowa Reading scores revealed that reading ability accounted for a significant amount of variance in post-test performance. A test of parallelism indicated that there were no significant differential effects by treatment for reading ability on post-test scores. Consequently, post-test scores were analysed with a one-way analysis of covariance using reading achievement as the covariate. The post-test mean scores, adjusted for reading ability, were 12.48 (S D =4.85) for the high-density group, 9.72 (SD = 5.34) for low-density, and 5.47 (SD = 3.95) for no questions. The analysis of covariance yielded a highly significant difference for question density, $F(2, 87) = 15.24$, $P < 0.001$. A posteriori contrasts revealed significant differences beyond the 0.01 probability level between all three pairs of means.

Question density and reading ability accounted for 26 per cent of the variance in post-test performance. Analysis of time on task revealed significant increases in the reading times occurred with each increase in question density ($P<0.001$). Conversely, time to complete test items did not differ significantly for high and low-density groups ($P>0.08$) while children in both conditions took significantly less time to finish their post-tests compared with those reading texts without embedded questions ($P<0.001$).

DISCUSSION

The results related to question density indicate that a high level of density of embedded post-questions does, in fact, enhance student learning. Children registered significant increases in achievement as density increased both from no questions to three per set and from three questions to six. Thus, high question density, at least for passages of similar length to the present one, does not appear to seriously diffuse processing attention or inhibit learning from the embedded post-questions.

The data also reveal that students across the entire range of reading ability benefited from embedded post-questions. This finding differs from that of Seretny and Dean (1986), who did not find a significant benefit for high readers, but it supports their explanation that the lack of effect for high readers in their study may have been due to a ceiling effect.

Finally, the results on question density have practical implications for the design of computer-based instruction. Applicability of the findings to CBI should be relatively strong because the high-density level from this study can be considered as high on an absolute basis and not just relative to the other treatments in the study. The six questions per set and one question per 38 words of text, or every two-to-three sentences, were designed to represent high absolute levels both for a single set and on a question-per-words basis. Instructional designers rarely exceed either level in developing computer-based instruction for the schools.

REFERENCES

ANDERSON, R. C. (1982). Allocation of attention during reading. In FLAMMER, A., and KINTSCH, W. (Eds.), *Discourse Processing.* New York: North Holland.

ANDERSON, R. C., and BIDDLE, W. B. (1975). On asking people questions about what they are reading. In Bower, C. (Ed.), *Psychology of Learning and Motivation. Vol. 9,* New York: Academic Press.

ENERGY SOURCE EDUCATION COUNCIL (1984). *Energy Source Program.* Washington, D.C.

KULHAVY, R. W., SCHWARTZ, N. H., and PETERSON, S. E. (1986). Working memory: the instructional encoding process. In Firm, G. D., and ANDRE, T. (Ed s.), *Cognitive Classroom Learning: Understanding, Thinking, and Problem Solving.* New York: Academic Press.

ROTHKOPF, E. Z. (1966). Learning from written instructive materials: an exploration of the control of inspection behavior by test-like events. *Am. educ. Res. J.,* 3,241-249.

SCHLOSS, P. J., SINDELAR, P. T., CARTWRIGHT, G. P., and SCHLOSS, C. N. (1986). Efficacy of higher cognitive and factual questions in computer assisted instruction modules. *J. comp.-based Instr.,* 13,75-79.

SERETNY, M. L., and DPAN, R. S. (1986). Interspersed post-passage questions and reading comprehension achievement. J. *educ. Psychol.,* 78 (3), 228-229.