Facilitating Learning From Technology-Enhanced Text: Effects of Prompted Elaborative Interrogation

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ABSTRACT The authors examined the use of the elaborative interrogation (EI) strategy with a lengthy text in a technology-enhanced environment. As commonly found in traditional and online text materials, questions appeared in the right margins of the text. Seventy-five randomly assigned volunteers in 2 conditions read instructional materials delivered by the Internet. Dependent measures included learning outcomes of free recall, recognition, and transfer tasks. At immediate and delayed testing, differences between higher order recognition questions and number of elaboration units recalled provided support for integrating EI prompts in technology-enhanced environments. Design suggestions for development and use of Web-based instruction materials in K–16 classrooms are discussed. Future research directions that more fully investigate EI and other strategy prompts within technology-enhanced materials are provided.

Key words: elaborative interrogation, technology-enhanced text, Web-based instructional materials in K–16 classrooms

A common problem faced by practitioners and researchers is that readers often face difficulties in learning from text materials (e.g., Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987; Robinson, 1998). Instructional designers and educational psychologists have long recognized the need to facilitate learners' text comprehension. The problems that learners face with learning from text are compounded when they are asked to access instructional materials outside of classroom instructional time. Instructors increasingly require that their students access electronic resources, particularly Web sites, to learn additional information about content covered in class.

In 1999, for example, more than half of all K–12 teachers in the United States assigned Internet research to their students; many of these teachers assigned the research for retrieval outside of class time (National Center for Education and Statistics, 2000). The current movement toward online and CD-ROM-based textbooks (e.g., Schick, 2001) will likely increase the amount of outside text-dense reading that instructors require. Thus, researchers must continue to search for strategies and text modifications that promote comprehension. Design specialists often suggest modifying text by including various enhancements to instructional materials (Mayer, 1999). Those additions, based on previous research and theory about how learners process text, are designed for educators to prompt and facilitate learner processing.

One approach to text processing is instructional design, which facilitates learner construction with supplements that are focused on helping the learner (a) address important information, (b) organize and elaborate on information to be learned, and (c) relate new information to prior knowledge. The Selection, Organization, and Integration (SOI) model (Mayer, 1996, 1999), for example, supports that practice. The SOI model suggests that by including a variety of text supplements or enhancements, instructional designers encourage learners to be cognitively active and to use strategies known to promote knowledge construction.

Many researchers have addressed the role of inserting various supplements as learning aids in instructional materials: for example, (a) text signals (Lorch & Lorch, 1995, 1996; Mautone & Mayer, 2001; Spyridakis & Standal, 1987) aid learner selection and attention to important information (b) graphic organizers, including diagrams, tables, and matrices promote learner summarization and organization (Kiewra, Kauffman, Robinson, DuBois, & Staley, 1999; Robinson, 1998; Robinson & Kiewra, 1995; Robinson & Schraw, 1994); (c) text illustrations and pictures help organization and integration with prior knowledge (Glenberg & Langston, 1992; Levin & Mayer, 1993; Mayer, Steinhoff, Bower, & Mars, 1995); (d) animation, which might facilitate several learner-processing strategies (Mayer & Moreno, 1998; Park, 1998; Park & Gittleman, 1992; Sperling, Seyedmonir, Aleksic & Meadows, 2003); and (e) adjunct or inserted questions that, depending on the level of questions, may promote deep-learner strategy use (see Anderson & Biddle, 1975; Hamaker, 1986, for reviews).

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Elaborative interrogation (EI) is another well-documented manipulation. EI supports learner knowledge construction by requiring learners to answer self-generated or "why" questions that are provided (Wood, Miller, Symons, Canough, & Yedlicka, 1993) so that students make connections with prior knowledge to promote deeper processing. The strategy has been useful and robust in a multitude of settings. The success of EI prompted researchers to test the strategy with various expository materials, including texts about animals (Willoughby, Waller, Wood, & MacKinnon, 1993; Wood, Pressley, & Winne, 1990), gender differences (Pressley, Symons, McDaniel, Snyder, & Turnure, 1988), Canadian provinces (Martin & Pressley, 1991; Symons & Greene, 1993), West German states (Woloshyn, Pressley, & Schneider, 1992), general science facts (Woloshyn, Paivio, & Pressley, 1994; Woloshyn & Stockley, 1995), Canadian universities (Woloshyn, Willoughby, Wood, & Pressley, 1990), and the human circulatory system (O'Reilly, Symons, & MacLatchy-Gaudet, 1998). Researchers found greater retention with EI strategies in young learners (Wood et al., 1990, 1993), adolescents (Wood, Willoughby, Kaspar, & Idel, 1994), and adults (Pressley et al., 1988), regardless of presentation formats such as isolated facts (Pressley et al., 1988), sequential facts (Willoughby et al., 1993), paragraphs versus isolated facts (Woloshyn, Willoughby, Wood, & Pressley, 1990), and paragraphs (Seiffert, 1993). EI is a versatile strategy that has been taught explicitly to learners (Wood, Fler, & Willoughby, 1992) and implemented as a text supplement for learners (e.g., Boudreau, Wood, Willoughby, & Sprecht, 1999; Seiffert, 1993).

Although EI has been studied extensively with various types of expository text, areas remain for future research. For example, few studies have investigated the effectiveness of the strategy when learners are engaged in reading longer passages (for exceptions, see Boudreau et al., 1999; Seiffert, 1993) or in texts presented in a technology-based environment (for exception see Dornisch & Sperling, 2004). The majority of the studies to date ask learners to recall what they remember from the text and to concentrate on the recall of specific facts rather than on their credible elaborations.

We addressed limitations in previous EI studies by examining the role of EI prompts on various learning outcomes and by drawing specifically from studies that test the ecological validity of the strategy (see Seiffert, 1994). By investigating the utility of the strategy in a fact-dense, descriptive expository text about the retail industry, we added to the literature by describing the utility of EI in facilitating learning from materials similar to those encountered in postsecondary coursework or job training. By engaging learners in reading a text longer than that typically used in EI investigations, we also added to the limited number of studies in which researchers used more lengthy text passages (e.g., Boudreau et al., 1999). In further deference to ecological validity, we inserted questions in the margins, consistent with instructional texts, to allow learners to consult the text when answering EI questions. In addition, as suggested by Robinson (1998), we tested participants a week after the original testing. Finally, by including a problem-solving transfer task, we examined an outcome measure that is infrequently addressed.

One research question guided this study and asked whether there are differences in performance on retention and transfer tasks between students who receive EI embedded in the margins of text versus those who receive repetition control (RC) instruction. We expected that participants in the EI condition would perform better on free recall at immediate and delayed testing. We also expected that participants in the EI condition would perform better on free recall at immediate and delayed testing. We assessed *recall* as both main idea units that supported idea units and the total of mean and supporting idea units at delayed and immediate testing. We predicted that the EI condition would outperform the RC condition on all types of recall measures at immediate and delayed testing.

We developed recognition test items to represent three levels of difficulty based on research by Pearson and Johnson (1978). In ascending order of complexity, the items represented text explicit (TE), text implicit (TI), and script implicit (SI) items. We hypothesized that participants in the EI condition would perform better on SI-recognition items but that there would be no difference in scores on TE- and TI-recognition items. We expected the same result for immediate and delayed testing. We also predicted that participants in the EI condition would perform better on a problem-solving transfer item administered at immediate testing. Table 1 provides a description of the research expectations.

Method

Participants

We randomly assigned 75 volunteer undergraduate students enrolled in introductory educational psychology courses at a large university to one of two treatment conditions—RC or EI. Participants were primarily in their sophomore year (n = 63), although several juniors (n = 7) and seniors (n = 5) also participated. Fifty-six participants were women, and 19 participants were men. Majors varied and included early childhood or elementary education (n = 33), secondary education (n = 22), special education (n = 3), workforce education (n = 2), communication disorders (n = 8), and other (n = 7). The average grade point average (GPA) that the students reported was 3.34 on a 4.0 scale, with no significant differences on self-reported GPA between the two groups.

The students initially completed a demographic questionnaire that collected information regarding their gender, academic year, age, current GPA, major, and prior knowledge of text topics. To determine prior knowledge of topics,

the students indicated their experience with business courses (no business course, $n = 58$; one business course, $n = 14$; two business courses, $n = 3$). On a poststudy inquiry, no participants reported reading the experimental text or any similar text prior to the study. We found no significant differences between the two conditions on the basis of prior knowledge. We also screened participants on the basis of several questions to assess perceived comfort with technology. Results from the demographic questionnaire warranted no further analyses. We did not exclude any participant data from the study on the basis of responses to those measures.

TABLE 1. Expectations for Learning Outcomes

Group	Condition
Immediate recall	
Main idea	EI > RC
Supporting idea units	EI > RC
Elaboration idea units	EI > RC
Total idea units	EI > RC
Delayed recall	
Main idea	EI > RC
Supporting idea units	EI > RC
Elaboration idea units	EI > RC
Total idea units	EI > RC
Immediate factual recognition	
Text explicit	EI = RC
Text implicit	EI = RC
Script implicit	EI > RC
Delayed factual recognition	
Text explicit	EI = RC
Text implicit	EI = RC
Script implicit	EI > RC
Problem solving	EI > RC

Note. EI = elaborative interrogation; RC = repetition control.

Experimental Text and Treatments

All participants accessed the base text, which consisted of a 2,096-word, 22-paragraph text describing retail, merchandising, and accounting principles. As is consistent with typical study materials, each paragraph of the text provided a topic sentence and supporting sentences. All materials were provided to students in a Web-based environment. The text was delivered in a format familiar to students who study text-dense information on the Internet. For both conditions, the entire text appeared on one Web page. If necessary, learners could scroll through the text and read it several times. However, we programmed the instructional text so that when participants completed their study of the text and were directed to dependent measures, they could not return to the instructional text.

In the RC condition, participants received the text with no enhancements and were directed to re-read until they felt comfortable with their comprehension in preparation for an upcoming assessment. In the EI condition, participants responded to questions such as, "Why would general merchandise planning begin at the department level?" and "Why might a retailer decide that it is better to have his own personnel taking physical inventories?" Directions indicated that students should generate answers to those questions and then type them into text boxes located adjacent to the text. The directions did not specifically direct the learner to activate prior knowledge, but they did indicate that the answers might not be stated explicitly in the text. The questions directed attention to main idea units but encouraged integration across text and integration of content with prior knowledge.

Figure 1 provides a screen shot of the instructional text and embedded questions as presented for participants in the EI condition. Except for inclusion of EI, the texts were identical across conditions. The entire text was presented on one page, so participants in each condition had access

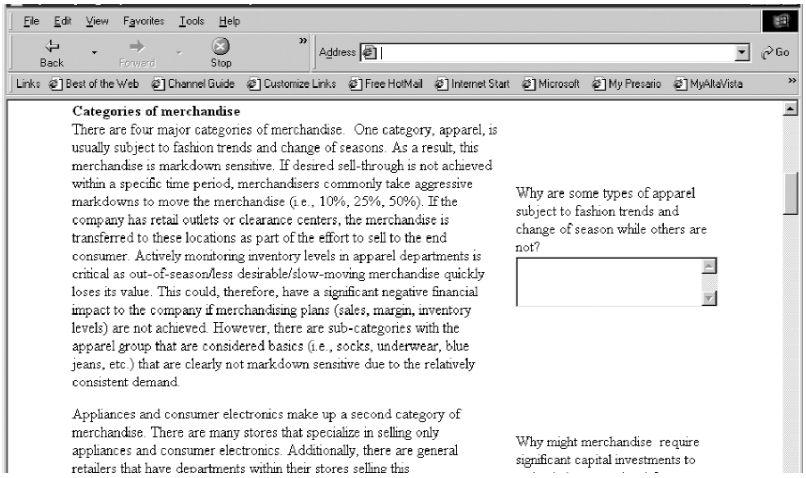

FIGURE 1. Example of text format.

to the text at all times while they studied the instructional materials. All EI questions appeared in the right margin in close proximity to the content to which they referred. As suggested in the literature, learners had control of the environment (Chen & Macredie, 2002; Niederhauser & Shapiro, 2003). For example, learners could scroll through the text and read at their own pace. If they were in the EI condition, the learners also could respond at their own pace, controlling the order in which they answered the questions. If the learners had difficulty answering a question, they could continue reading the text and return to the question later. That process addressed criticisms of the ecological validity of questioning research (see Duchastel, 1983; Spring, Sassenrath, & Ketallapper, 1986).

Dependent Measures

Corresponding criterion tasks included (a) an immediate free-recall test; (b) a four-alternative, multiple-choice recognition test; and (c) a problem-solving transfer item. We also administered identical free-recall and recognition tasks after 1 week, consistent with previous recommendations (Robinson, 1998).

Free recall. Rather than having many prompts asking learners to recall specific information from the text, the free-recall task asked learners to write down everything that they could remember about the text they had read, without concern for spelling, grammar, or formatting. By scoring the free-recall task, we captured connections that students may have made to prior knowledge by including learner-generated elaborations. Using a common parsing scheme (e.g., Bovair & Kieras, 1985), we parsed the text to identify all the main idea units and supporting idea units prior to scoring the free-recall data. Figure 2 provides an example of the parsing scheme. Consistent with Bovair and Keiras, we scored participants' statements as correct if they were recalled verbatim or preserved the original meaning. We also scored recall answers for evidence of integration of prior knowledge. We termed novel examples and outside elaborations spontaneous EI units, which we considered to evidence integration of prior knowledge for learning.

Recognition. The recognition task included 20 items focused on three types of information: TE, TI, and SI questions. *TE questions* focused on information found directly in the text and located in one sentence such as, "Jewelry at___are consistently offered at markdown prices." *TI questions* focused on information found directly in the text but located in more than one sentence, across sentences or paragraphs. An example of a TI question is, "Which of the following is a performance measure for receiving?" *SI questions* focused on information implied in the text (Pearson & Johnson, 1978). An example is, "Which of the following stores is most likely to remain open during the physical inventory observation (PIO) than the others?" The answers that students could choose were stores not mentioned in the text. The recognition questions were provided in a four-alternative, multiple-choice format.

Problem-solving transfer. The problem-solving transfer task required that learners use information provided and implied within the text to describe steps for resolving a problem that might be encountered by a retail consultant. We developed a 6-point scoring rubric for the problem-solving transfer task that was based on, and adapted from, a scoring rubric used by Guthrie and colleagues (1998) in a study directed at generative learning. Scoring reliability was established by multiple re-visits to answers until two researchers agreed on the categorization of each answer. Table 2 provides the 6-point rubric.

Procedures

We recruited participants during their regularly scheduled class time; they received extra credit for their participation. The students signed up for one of the multiple sessions conducted in university computer labs; we randomly assigned the volunteers to one of two conditions—RC condition or EI condition. Prior to beginning the experiment, all participants received the same instructions.

The students next read the instructional text, then completed a 10-item situational interest survey developed by Schraw, Bruning, and Svaboda (1995). We included the interest survey to reduce recency effects and to avoid possible ceiling effects on the recognition task. As such, the

CM1[a]	There are categories of merchandise
CS1[b]	Four
CM2	Apparel
CM3	This merchandise is markdown sensitive
CS1	Subject to fashion trends
CS2	Change of seasons
CM4	Merchandisers commonly take aggressive markdowns to move the merchandise
CS3	If sell-through is not achieved within a specific time period
CS4	10%, 25%, 50%
CM5	Merchandise sent to retail outlets or clearance centers in effort to sell to end consumer
CS6	If company has retail outlets
CM6	Actively monitoring inventory levels is critical
CM7	Merchandise quickly loses its value
CS6	Out-of-season/less desirable/slow-moving
CM8	Negative impact in merchandising plans (sales, margin, inventory levels) not achieved
CM9	Subcategories considered basics
CS7	Socks, underwear
CS8	Bluejeans

FIGURE 2. Example of free-recall parsing scheme.
[a]CM refers to main idea unit in category section of text.
[b]CS refers to supporting idea unit in category section of text.

TABLE 2. Rubric for Scoring Solutions to the Problem-Solving Task

Number	Example
0	No transfer: Answer does not express any knowledge, or answer is not based on stated problem.
	First, I would find out what went wrong in the planning stages, then I would find out about the distribution stages and determine what has gone on. Someone had made an error along the way.
1	Incomplete transfer: Answer contains only one solution (or theme) to the problem.
	Check to determine whether some inventory is on display, in lunch rooms of workers, in other places than just the sales floor.
2	Partial transfer: Answer contains two solutions (or themes) to the problem.
	I think that if it is a major difference, I would maybe try to recount the merchandise. Then if I still came up with a wrong count, I would check all the backrooms and anywhere else there may be any merchandise, such as offices, or advertising areas. I would ask the employees if they knew where the damaged merchandise went, because that is an important part of the inventory that might have been overlooked.
3	Surface transfer: Answer contains more than two solutions with surface rationale.
	I would first do a recount to make sure that I was not at fault. If I still came up with a different amount, I would check my equipment to make sure it was functioning correctly. If after this I still had a lower count than the store's records, I would notify the store manager and have the manager talk to the personnel who did the count and have them do a recount. Then, if a difference still was seen, I would have the store bring in a third party to do a count and settle the matter.
4	Justified transfer: Answer contains multiple solutions with some justification or reasoning.
	The first step in assessing this problem is to get in touch with the distributors to compare inventory sheets and determine where the problems lie. In doing so, you will be able to determine if you should be receiving more inventory than what you already have. If so, you can ask the distributors to send out the rest of the shipment. However, if the mistake was on your part, you will have to take different actions. You can put less of the merchandise out on the floor at a time, or put it in a location where it is not as easily accessible. Also, talk to the store manager to determine what he or she would like you to do. Make sure to change the inventory count so that there are no discrepancies in the future.
5	Systematic transfer: Answer contains solution strategies with supporting rationale.
	First, I would have another person and I count it again to make sure it was not a mistake on my part. If it were still lower, then I would check the back of the store for merchandise that has not been put out yet. If it were still lower, then I would not question it until the end when everything has been counted because some items could have been misplaced or returned. If finally it was still lower, I would subtract the allowed shrinkage and determine how much percentage of the merchandise was still missing. I would let the store managers know and give them some possible reasons and things to look out for in the future. Tell them to be real careful with theft, both internal and external, and make sure that all employees know to write all damaged merchandise and marked-down merchandise in the book and to carefully count all merchandise as it is coming in to make sure that the mistake is not on the vendor's part.

interest measure controlled learner processing and was, therefore, not a variable addressed in this study. The answers to the inventory were not analyzed. Overall, however, no extreme ratings on the interest items were indicated, and we deemed learner interest in the materials as neutral. To be specific, out of a possible total score of 40—the sum of the 10 interest items scored as follows: 0 (*strongly disagree*), 1 (*disagree*), 2 (*neutral*), 3 (*agree*), 4 (*strongly agree*)—participants rated their interest in the text materials as neutral ($M = 21.24$), and no significant differences occurred in interest ratings between the two conditions.

After completing the interest survey, students completed the instructional materials by answering a free-recall prompt, recognition questions, and a problem-solving

transfer item. Participants returned to the computer lab 1 week later for a delayed administration of the free-recall and recognition criterion tests.

Analysis

We conducted multiple *t* tests to examine between-group differences. We also calculated effect sizes for interpretation, given the number of *t* tests conducted. The findings from significance tests and an evaluation of effect sizes provide support for some of the research expectations.

Free Recall

We computed independent *t* test analyses to determine differences between the two groups on recall. No differences between the two conditions were apparent when we totaled main idea units, supporting idea units, and elaboration idea units, $t(73) = .262$, $p = .29$. Means and standard deviations for immediate free-recall main idea, supporting idea, spontaneous elaborative idea, and total idea units are shown in Table 3.

Because university learners are familiar with reading text information for upcoming assessments, we expected that the benefits of the treatment condition would be more salient at delayed testing. We also expected that participants in the EI group would have a more cohesive knowledge base and therefore recall more than would the RC group at delayed testing. At delayed testing, as for immediate recall, however, no differences between the two conditions were apparent when we totaled main idea units, supporting idea units, and elaboration idea units, $t(73) = -1.068$, $p = .29$. Although no statistically significant differences occurred between the two conditions on free-recall scores, data indicated a different pattern of means from those at immediate recall. That is, at delayed testing, the mean for EI was higher than that for RC, but at immediate testing, there was no apparent benefit for EI. Means and standard deviations for delayed free recall are shown in Table 3.

Factual Recognition

We expected that the participants who had elaborated on the text during the study would have a better overall understanding of the text rather than of specific facts within the text, and they would therefore be able to integrate their knowledge of the text with prior knowledge at testing. We anticipated that participants in the EI conditions would score higher on SI questions than would those in the RC condition at immediate and delayed testing. We further hypothesized that some loss of specific text information in the EI group would occur at delayed testing.

For immediate testing, we computed independent *t* test analyses to determine differences on the overall recognition score, $t(73) = -2.16$, $p = .03$. Means and standard deviations for immediate recognition data are presented in Table 4. We also computed independent *t* test analyses to determine differences at delay for recognition performance. We expected that the EI condition would suffer some loss of specific text information at delay. There were no differences in overall recognition, $t(73) = -1.847$, $p = .07$, indicating a loss of some specific information on the part of the EI condition. However, commensurate with immediate testing, patterns in the data indicated a slight benefit for EI over RC in both types of questions derived specifically from the text (TE and TI) on questions implied within the text (SI) and in overall recognition. Means and standard deviations for delayed recognition data are presented in Table 4.

TABLE 3. Means and Standard Deviations for Free Recall and Problem-Solving Transfer

	M		*SD*		
Group	Repetition control ($n = 38$)	Elaborative interrogation ($n = 37$)	Repetition control ($n = 18$)	Elaborative interrogation ($n = 37$)	p[a]
Immediate recall					
Main idea units	14.03	12.24	10.07	8.88	.419
Supporting idea units	6.05	6.51	5.36	5.18	.706
Elaboration idea units	.24	.68	.49	1.16	.038
Total idea units	20.32	19.43	14.81	14.41	.294
Delayed recall					
Main idea units	9.18	10.11	5.83	7.14	.541
Supporting idea units	4.08	5.19	3.49	4.20	.216
Elaboration idea units	.42	1.00	.86	1.58	.055
Total idea units	13.68	16.30	9.10	11.94	.289
Problem-solving transfer	2.76	2.65	1.44	1.49	.737

[a]The Bonferroni adjustment was $p < .005$ when all presented *t* tests were examined.

TABLE 4. Means and Standard Deviations for Factual Recognition Data

Group	*M*		*SD*		
	Repetition control (n = 38)	Elaborative interrogation (n = 37)	Repetition control (n = 38)	Elaborative interrogation (n = 37)	p[a]
Immediate recognition					
Text-explicit questions	3.52	3.81	1.31	1.04	.304
Text-implicit questions	4.21	4.38	1.14	1.16	.530
Script-implicit questions	2.81	3.70	1.59	1.24	.009
Total recognition questions	10.55	11.89	2.89	2.44	.034
Delayed recognition					
Text-explicit questions	3.74	3.92	1.22	1.23	.534
Text-implicit questions	4.05	4.22	1.56	1.32	.625
Script-implicit questions	2.81	3.62	1.47	1.44	.019
Total recognition questions	10.61	11.76	2.94	2.43	.069

[a]The Bonferroni adjustment was $p < .005$ when all presented t tests were examined.

Problem-Solving Transfer

We hypothesized that participants in the EI condition would perform better than would those in the RC condition on the problem-solving transfer task. An independent t test analysis determined that no significant differences occurred between the problem-solving transfer performance of the two conditions, $t(73) = .338$, $p = .73$. Means and standard deviations for RC and EI were similar (M = 2.76, SD = 1.44; M = 2.65, SD = 1.49, respectively) and are shown in Table 3.

Effect Sizes

A number of researchers have suggested that limitations of significance testing indicate supplemental analysis (Baugh & Thompson, 2001). One such analysis is effect size, which estimates "the magnitude of a difference, a relationship, or other effect in the population represented by a sample" (Gall, Borg, & Gall, 1996, p. 758). Some researchers believe that there are situations in which statistically insignificant findings can be noteworthy, whereas findings that are statistically significant may be uninteresting (Baugh & Thompson). Thus, effect sizes help to further describe whether statistically significant or insignificant differences in the data are meaningful.

To further investigate whether there were any effects of interest in the data, we calculated effect sizes for several of the tests. Of particular interest was that for immediate SI-recognition questions, the effect size was .60; for immediate total recognition questions, the effect size was .49; for delayed SI-recognition questions, the effect size was .54; and for immediate elaboration idea units, the effect size was .48. Given the characteristics of the learners and the nature of the text and task, those moderate effect sizes provide additional evidence that supports our hypothesis that EI may facilitate learning over RC and provide support for continued research into possible benefits of an EI strategy.

Discussion

We found no significant differences for immediate recall, indicating that elaborative interrogation did not encourage learners to attend more directly to, or to select, important information over repetition control. Those findings may be attributable to the instructional materials used by the learners. Prior studies that reported differences on recall measures between EI and RC focused primarily on ambiguous facts (Pressley et al., 1987; Pressley et al., 1988), isolated facts (e.g., Woloshyn et al., 1990), and sequential facts (e.g., Willoughby et al., 1993). The authors scored recall data in those studies primarily for recall of main ideas (e.g., Boudreau et al., 1999; Seiffert, 1994).

Because researchers in previous studies focused on recall measures on specific text content and questions directed learners' attention to that content, EI was more likely than was RC to facilitate selection. In the present study, we focused on recall measures on everything that learners could recall from text, and each sentence was parsed for main idea units and supporting idea units. We constructed elaborative questions to foster integration of prior knowledge and cross-text integration, and, therefore, did not direct learners' attention to any specific text content, thereby potentially limiting any significant effect.

University students are familiar with reading text information for upcoming assessments; therefore, we expected that the benefits of the treatment condition would be more salient at delayed testing. As at immediate testing, however, there were no significant differences at delayed testing between conditions for recall. Examination of the means indicates that although descriptively RC performed better on main idea units at immediate testing, that was not the case at delayed testing. That finding suggests that future work should examine delayed testing because the benefits of EI might be more salient at delayed testing. Those benefits might be enhanced by a longer study time. Students in this study had approximately 45 min to learn the instructional materials. Although no students elected to study longer, further study might be necessary for learners to realize the benefits of EI.

Because recognition questions were not redundant to the questions that were embedded in margins of the text that learners used at study and because learners engaged in reading longer texts rather than in reading isolated or sequential facts from many previous EI studies, we did not expect that EI would facilitate selection of the specific facts from the text. Thus, we anticipated no differences, either at immediate or delayed testing, between the two groups on TE- or TI-recognition questions. Results from recognition data, at immediate and delayed testing, supported those predictions.

We hypothesized that participants who elaborated on the text during study would have a better understanding of the text rather than just facts within the text, and that they would therefore be able to integrate their knowledge of the text with prior knowledge at testing. We expected that participants in the EI conditions would score higher than those in the RC conditions on SI questions at immediate and delayed testing.

Results for SI questions did not fully support our predictions. Unlike free-recall data, and consistent with Dornisch and Sperling (2004), no evidence indicated increased effect at delayed testing. There was some evidence of a continued effect for EI in SI questions and overall recall at delayed testing, but mean scores for both conditions remained fairly consistent for these questions.

There were no significant differences between the two study conditions on problem-solving transfer. On the basis of Mayer's (1999) suggestion that elaborative questions facilitate integration and therefore transfer, we predicted that EI would facilitate performance on problem-solving transfer. One possible explanation for the failure of EI to facilitate problem-solving transfer in this study is that, as evidenced by lack of significant differences on retention tasks, participants did not cultivate the necessary conceptual and procedural knowledge during study. According to cognitive theory, successful transfer is dependent on a well-developed knowledge base (Salomon & Perkins, 1989), which may not have been developed by learners in this study. Future studies might include several types of problem-solving transfer questions requiring varied forms of transfer.

Overall, there was little student achievement in the present study. Lack of interest in text topics may be one explanation for our results. Hidi and Harackiewicz (2000) argued that interest plays a major role in human cognition and remembering. For example, researchers have indicated that high text-based situational interest is a powerful determinant of learning and comprehension (see Hidi & Harackiewicz; Schraw & Lehman, 2001, for reviews). Learners are therefore much more likely to devote time and attention to learning text materials if the topic under study has some interest to them.

Researchers need to focus on the durability of EI for learners who engage in reading longer texts that are similar in style to texts that they might encounter in formal learning environments. Because text-supplement investigations sometimes indicate that advantages of the supplements disappear at delayed testing (e.g., Robinson & Schraw, 1994), findings of even minimal effects of the strategy at 1-week delay suggest that when used with appropriate texts and in suitable learning conditions, the strategy may be durable.

Unlike questions that learners often encounter, answers to EI questions are not found within the text. EI prompts require learners to respond to "why" questions by integrating text materials with prior knowledge. As such, answers to EI prompts may be speculative and lack a single "right" answer. Students were required to answer all questions in this study; they might have had difficulty answering the questions as we intended. Even when students answered the EI questions, they might not have elaborated on the content. It is possible that learners had little familiarity with that type of questioning strategy and simply tried to locate answers in the text. Future research should investigate whether students are able to answer elaborative questions when embedded in online environments. If students are unable to answer EI questions, future investigations should engage students in training within the EI environment to ensure that they understand what types of responses are optimal when faced with this strategy.

Research indicates wide variation in the training that educators need to successfully instruct learners in reading strategies. The required training ranges from a single direct prompt to intricate multiphase and multistep training. Dornisch and Sperling (2004) provided minimal written directions to prompt learners to use EI, and Ozgungor and Guthrie (2004) told participants to simply answer questions. In contrast, numerous strategy interventions require long-term interventions with substantial teacher and student commitment (e.g., Pressley et al., 1992). Researchers should investigate the amount of training necessary to facilitate learners' successful use of EI; learners also could comment on the strategy and its effectiveness for learning from text.

This study is one of few that take advantage of Web-based technology to experimentally examine the effects of text enhancements on student learning. The dearth of research in technological environments is problematic

given the frequency with which learners are required to learn from technology-rich instructional environments (National Center for Education and Statistics, 2002). However, we considered one capability of such technology: the placement of questions in margins of texts. Many other opportunities are available with Web-based delivery. Hypertext, for instance, provides opportunities to build learning environments that supply links to other materials during study. If learners who are asked to answer elaboration questions during study cannot activate appropriate background knowledge, the inclusion of links to materials that further activate prior knowledge could help learners answer the questions. Future studies should incorporate and examine the effects of hyperlinks for that purpose.

We also extended research on the benefits of EI prompts. The implementation of technology-enhanced text and use of longer texts similar to those from which university students would be expected to learn tested the known benefits of EI in ecologically valid settings. Findings support the belief that EI can help learners recognize inferences found in text and that some benefit for EI is likely identified at delayed testing. On the basis of our findings, researchers should continue to examine and test design modifications to technology-enhanced instructional materials because learners are increasingly exposed to similar learning environments. Also on the basis of our results, further research that addresses the roles of interest and motivation in the application of prompted learner strategies is warranted.

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