Contribution of Reading Skill to Learning from Expository Texts

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Abstract

Our study investigated the importance of reader aptitudes (prior knowledge and reading skill) in the processing of an expository text. We analyzed self-explanations produced by 42 high-school students while reading an expository text about thunderstorms. Specifically, we focused on students' attempts to paraphrase information (i.e., restate sentences in their own words) and elaborate on the sentence content (e.g., connect information in different sentences to build a global representation of the text). Our findings suggest that reading skill is important for the active processing of expository texts. Skilled readers produced more elaborations than less skilled readers, and also a more diverse range of strategies, which may be crucial for supporting learning. Implications for learning from text are discussed.

Introduction

Successful reading comprehension requires the efficient co-ordination and integration of a number of underlying processes (Vellutino, 2003). These processes may include identification of words, decoding of word meanings, integrating the meaning of individual words into a coherent sentence level meaning using sentence syntax, and finally building a more global level representation of the text by continuously integrating the individual sentences into meaningful discourse level representation.

Our focus is on the higher level processes involved in reading comprehension, in particular, on how readers construct global mental representations of situations, and/or topics described by written material (van Dijk & Kintsch, 1983). Further, we focus on the impact of two reader-related factors on reading comprehension at this higher level of processing.

The first of these factors concerns the readers' knowledge of the topic of the text. As readers comprehension processes move from lower levels (e.g., word meaning) to higher levels (e.g., sentence/discourse processing), comprehension becomes increasingly influenced by the reader's knowledge about the topic of the text (Kintsch, 1988). General knowledge clearly influences the comprehension of narrative text (e.g., McNamara & McDaniel, 2004). Moreover, general and domain-specific knowledge is particularly critical for successful comprehension of expository texts (e.g., chemistry, biology). A great deal of research has shown that readers' knowledge facilitates comprehension and learning from expository texts (e.g., Chiesi, Spilich, & Voss, 1979; McNamara & Kintsch, 1996).

However, there are reasons to believe that other individual difference factors influence higher level processing of texts. In particular, factors associated with general reading skill, such as working memory capacity (Just & Carpenter, 1992), reading strategy knowledge (Guthrie, Anderson, Alao, & Rinehart, 1999), and meta-cognition (Baker, 2002) appear to be important. For example, McNamara and colleagues (McNamara, in press; O'Reilly, Best, & McNamara, in press; O'Reilly, Sinclair, & McNamara, in press) have shown that meta-cognitive reading strategy training improves science text comprehension, particularly for low-knowledge readers. Thus, active, strategic processing of text is particularly important to the comprehension of expository texts.

We explore here how reading skill is beneficial to comprehension of expository texts beyond the impact of prior knowledge found in various past research (e.g., Chiesi, Spilich, & Voss, 1979). A possibility explored here is the notion that general reading ability is associated with a set of skills that facilitate active processing of expository texts.

We hypothesized that knowledge level and reading ability would be associated with different aspects of the reading comprehension of expository texts. Specifically, whereas “knowledge” should be important for how easily one can comprehend the material, “reading ability” or “skill” should influence active, deep level processing of the material. Thus, our goal in this paper is to examine how reading ability as well as prior knowledge contributes to the “process of learning” from expository texts. We use the phrase “process of learning” here to refer to the processes engaged by students to acquire new
According to constructivist framework, learning occurs as a function of constructive activity one engages at the time of processing the materials (Cobb, 1994). We hypothesized that reading ability is associated with a set of skills that help readers engage in constructive activities such as elaborative inferences during reading, hence contributing to learning from the materials.

To tap into the effect of reading ability on “the process of learning,” we analyzed self-explanations students produced when reading an expository text. Think aloud protocols are known to be useful for obtaining an insight into thought processes associated with problem solving (e.g., Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Ericsson & Simon, 1993) and reading (Chi, 2000). Evidence further indicates that eliciting self-explanations during reading leads some readers to engage in active reading strategies that improve text comprehension (Chi, de Leeuw, Chiu, & Lavancher, 1994). Finally, there is evidence showing that the number of self-explanations (e.g., elaborative inferences) is correlated with learning (Chi, 2000). These studies reveal strong relations between self-explanation and the “process of learning.” Thus, the analysis of self-explanations should afford an effective method of gaining insight into the “process of learning” that occur while students are reading expository texts.

Method

Participants

The sample consisted of 42 eighth and ninth grade children from an east coast suburban school. The students were enrolled in a learning program, called Learning Bridge, designed to provide summer school to students from under-privileged backgrounds.

Design and Materials

Individual differences were measured with two tests; a modified version of the Gates-MacGinitie Reading Skill Test and a Prior Knowledge Test. The Gates-MacGinitie test is a standardized reading comprehension test, designed for grades 10-12. The test consisted of 40 multiple-choice questions that assess students’ comprehension on several short text passages (Cronbach’s Alpha $\alpha = .91$). Due to time constraints we omitted the vocabulary comprehension section. The prior knowledge test had 35 multiple-choice items, which tap knowledge of different science domains, including biology, scientific methods, mathematics, earth science, physics, and chemistry (Cronbach’s Alpha $\alpha = .81$).

The iSTART system (McNamara et al., in press), in which the self-explanations were collected, consists of three phases: Introduction (introduces concept of self-explanation and reading strategies), Demonstration (shows users examples of self-explanation) and Practice (requires students to generate self-explanations).

In the practice section, students are presented with science texts one sentence at a time on the computer screen. For each sentence, they are asked to type a self-explanation. iSTART assesses the quality of the self-explanation and provides the feedback to students via the pedagogical agent, Merlin. The feedback is largely based on the degree of argument overlap between the students’ self-explanation and the target sentence. The system is designed such that it encourages students to use information that is not in the target sentence (e.g., elaboration based on commonsense and previous sections of the text). For example, Merlin might respond with “Try adding some more information that explains what the sentence means” when the self-explanation is too similar to the target sentence. Thus, feedback differs for each user, depending on the quality of self-explanations produced.

The self explanations analyzed in this paper are the final versions that the students provided for each sentence. Thus, they have been affected by the feedback of the system in that the final self-
explanations reflect better quality protocols than would otherwise have been provided under spontaneous circumstances. However, the system tends to reduce the difference between high and poor quality self explanations because there is a certain threshold for the acceptance. In this sense, the effects of individual differences reported in this paper are unlikely to be artifacts of the system's feedback.

Students self-explained two texts in the practice phase, “Stages of Thunderstorm Development” and “Origin of Coal.” The present analysis focuses on self explanations for the thunderstorm text. This text, which was extracted from a school textbook, has 13 sentences and 197 words, with Flesch-Kincaid Grade level of 9.4.

Procedure

Individual difference measures were collected shortly before iSTART training. Students completed the prior knowledge test followed by the Gates-MacGinit reading test. They were given 15 minutes to complete each assessment. The students then completed the training with iSTART program. During the practice phase, they provided explanations to the Thunderstorms text.

Coding

Students typed their self-explanations, which were automatically recorded in the database. Two independent coders analyzed the self-explanations in terms of the following five dimensions: 1) presence of comprehension monitoring; 2) presence of paraphrasing (none, topic identification, repetition, and paraphrasing); 3) distance of paraphrasing from the target sentence; 4) accuracy of the paraphrasing; and 5) presence of elaborations.

Coding of comprehension monitoring assessed whether self-explanations incorporated the monitoring of students’ understanding. Explanations were coded for the presence or absence of comprehension monitoring statements (e.g., ‘I don’t understand X’). The presence of paraphrasing was judged on students’ attempt to restate the target sentence in their own words. For this coding, a self explanation was categorized as one of the following: 1) a paraphrase that was a restatement of the sentence using different words, 2) a repetition of the sentence that was lexically too similar to the target sentence, 3) a simple topic identification (e.g., ‘this is about storms’), or 4) no paraphrase, repetition, or topic identification. If the explanation was categorized as a paraphrase, the paraphrase was further coded for accuracy and distance from the target sentences. Accuracy has three levels (inaccurate, partially accurate, and accurate); and distance has two levels (distant and close). Close paraphrases were closely aligned to the original sentence in terms of sentence structure and/or content words. Distant paraphrases contained the same semantic content as the target sentence, but did not have the same sentence structure or content words.

Coding of the elaborations was based on whether the self-explanations included any ideas that were not explicitly present in the target sentence. Once a self-explanation was found to contain an elaboration, it was further coded for the nature of its contribution: 1) relevant to the comprehension of neither the current sentence nor the overall text; 2) relevant and contributes to the comprehension of only the target sentence; and 3) relevant and contributes to a global level of comprehension that goes beyond the current sentence (e.g., actively building the large picture depicted by overall text). We also coded the elaborations in terms of their source and accuracy. However, since the present analysis does not focus on these aspects, they are not described here (see Best et al., 2004).

Reliability of the coding was evaluated using Cohen’s Kappa and simple agreement (when the coding is binary). Reliability between the coders was 85% or above for all coding dimensions. Disagreements were resolved via a discussion between the coders.

Results

To explore the role of the reading skill and prior knowledge, we adopted a median split method; students were divided into high and low reading comprehension skill, or high and low-knowledge groups, using the median scores of The Gates-MacGinit test or Prior Knowledge test. The correlation between the Gates-MacGinit test and the prior knowledge test was high, $r = 0.604, p < .001$.

Our data indicated that students’ often attempted to paraphrase (91.0%) and elaborate (41%), but seldom expressed comprehension monitoring (4%). Thus, the subsequent analysis focuses on paraphrase and elaborations.

We used analysis of variance (ANOVA) to analyze the students’ use of the strategies. The univariate ANOVAs comprised reading skill (high or low) or knowledge (high or low) as the between-subjects factor and strategy type (e.g., paraphrases) as the dependent variable.

Frequency distribution of strategy use

Our first analysis investigated the frequency of four types of strategy used by different types of readers (low and high reading skill or knowledge students). For this analysis, we classified all the self-explanation into one of four categories: 1 =
Repetition or topic identification only; 2 = Paraphrasing only; 3 = Elaboration I (irrelevant or current sentence); and 4 = Elaboration II (knowledge building).

It is important to note that elaboration (both type I and II) may or may not contain paraphrasing. Elaboration I and Elaboration II were treated separately because knowledge building elaborations are indicative of the investment of a greater effort to understand the text (i.e., building a more global representation of the text). Irrelevant elaborations were coded under Elaboration I because they indicate that the student is investing an effort to integrate the information into their knowledge structures.

The levels of the classification scheme reflect an increase in the construction of integrated and global representations of the situation described by the text. For example, repetition does not require any integration because it only involves rewriting the text information. In contrast, paraphrasing requires the restatement of the situation using different words or sentence structure, revealing how students understood the meaning of the sentence. Similarly, Elaboration I indicates that students are making an effort to understand the target sentence by relating, integrating, or comparing the information in the sentence with what they already know. Finally, Elaboration II involves effort to integrate information appearing on a multiple sentences into a coherent model. Therefore, this analysis can examine the degrees of constructive activities carried out by the student.

The first analysis investigated the self-explanation strategies used by skilled and less skilled readers. As shown in Table 1, skilled readers were more likely to use elaboration strategies whereas less skilled readers were more likely to repeat or paraphrase only.

We performed two separate ANOVAs, assessing the frequency with which skilled and less skilled readers used elaboration types I and II. Skilled readers produced more current sentence focused elaborations (elaboration I), $F(1, 39) = 6.75$, $MSE = .053, p = .01$, and knowledge building elaborations (elaboration II), $F(1, 39) = 7.6, MSE = .003, p < .01$, than did less skilled readers. The difference between skilled and less skilled readers in current sentence focused elaboration (Elaboration I) is not solely attributable to irrelevant elaborations included in Elaboration I because the difference remained marginally significant after excluding irrelevant elaborations: (less skilled readers $M=.22 SD=.22$) and (skilled readers $M=.33 SD=.20$), $F(1, 39) = 2.95, MSE = .043, p = .094$.

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<th>Table 1. Strategy use and comprehension skill</th>
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Note: Standard deviations are in parentheses.

The previous analysis was repeated with knowledge as the between-subjects variable. As shown in Table 2, there were few differences in the distribution of strategies used by high and low-knowledge readers. ANOVAs confirmed this conclusion: there was no difference in the frequency with which low-knowledge and high-knowledge students used Elaboration I, $F(1,39) = 1.04, p = ns$, or Elaboration II, $F(1, 39) = .017, p = ns$. There was no difference, again, in Elaboration I even after excluding irrelevant elaborations: low-knowledge ($M=.28 SD=.24$) and high-knowledge ($M=.28 SD=.19$) students.

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<th>Table 2. Strategy use and knowledge</th>
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Variety of strategy use

Next, we were interested in how skilled and less skilled readers and high and low-knowledge readers differed in terms of the diversity of the strategies they use in self-explaining the 13 sentences of the text.

We hypothesized that less skilled readers would be relatively uniform in their strategy use (i.e., use only one type of strategy). In contrast, skilled readers would frequently change their strategy use (i.e., adapt their strategies to different sentences). On the other hand, we predicted that knowledge level would make little difference in terms of the variety of strategies students’ used.

To conduct this analysis, we counted how many of the aforementioned strategies (paraphrase, type I elaboration, and type II elaboration) each student used to self-explain the 13 sentences. We did not count repetition/topic identification as a strategy because it is a default technique. Accordingly, the
score each student obtained varied from 0 (no strategy used) to 3.

The analysis showed that reading skill was an important determinant with regard to the variety of self-explanation strategies used. An ANOVA indicated that skilled readers used a greater variety of self-explanation strategies ($M = 2.4, SD = 0.6$) than did less skilled readers ($M = 2.0, SD = 0.5$), $F(1, 39) = 5.9, MSE = .277, p = .02$.

On the other hand, the analysis based on readers’ knowledge indicated that there was no reliable differences in the range of self-explanation strategies used by high ($M = 2.3, SD = 0.5$) and low-knowledge students ($M = 2.1, SD = 0.3$), $F(1,39) = 1.45, ns.$

**Effect of prior knowledge and reading skill on the quality of paraphrases**

Thus far, our analyses have indicated that reading skill, rather than prior knowledge is an important factor in determining the frequency of elaborative inferences and variety of self-explanation strategies students employ. Does this mean that prior knowledge does not play an important role in the reading comprehension process? According to our argument, and existing literature, prior knowledge should have a large influence on comprehension level of expository texts. In order to examine the effect of prior knowledge on comprehension, we analyzed the quality of paraphrases. Given that paraphrasing involves describing the gist of a sentence using one’s own words, the quality of paraphrases should reflect the students’ understanding of sentence meaning.

Our analysis focused on two different qualities related to successful paraphrasing: 1) accuracy of the paraphrase and 2) distance of the paraphrase. For accuracy, a score of 0, 0.5 and 1.0 was assigned for inaccurate, partially accurate, and accurate paraphrases, respectively. The two sets of univariate ANOVAs on the accuracy scores indicated that there were no effects of individual differences. This rather disappointing result is possibly due to the fact that the target sentence was available for reference while students self-explained the sentence.

Turning to the distance of paraphrase, we compared the frequency of distant paraphrases produced by high and low-knowledge and/or by skilled and less skilled students. Two sets of univariate ANOVAs on the frequency of distant paraphrases indicated that distant paraphrases occurred more frequently for high-knowledge ($M = 0.63, SD = 0.22$) than low-knowledge students ($M = 0.44, SD = 0.24$), $F (1, 39) = 8.153, MSE = .051, p <.01$. Also the main effect of reading comprehension skill was marginally significant, with more distant paraphrases produced by skilled readers ($M = 0.61, SD = 0.29$) than less skilled readers ($M = 0.47, SD = 0.24$), $F (1, 39) = 2.891, MSE = .057, p = .097$.

We also examined accuracy of distant and close paraphrases by dividing all of the items into distant or close paraphrases, and analyzing whether the accuracy differed across distant and close paraphrases. The analysis revealed that accuracy does not differ between distant ($M = 0.62, SD = 0.22$) and close paraphrases ($M = 0.69, SD = 0.20$), $F(1, 38) = 2.215, p > 0.1$, suggesting that distant paraphrases are not necessarily less accurate. Overall, these analyses indicate that students’ prior knowledge has a larger effect on the production of distant paraphrases. Given that producing a distant paraphrase without distorting the meaning of the sentence requires accurate production of the sentence, this finding confirms previous findings for effects of knowledge on comprehension level of the sentence.

**Discussion**

Overall, the analyses support our prediction that reading comprehension ability is closely associated with the effort and strategies that readers expend to understand the expository text, whereas knowledge is more closely associated with the actual comprehension level of the material (as indicated by the distance of the paraphrase analysis). Skilled readers’ self-explanations tend to include more constructive activities, such as elaborative inferences and linking different parts of the text to obtain a “larger picture.” This finding is remarkable because it demonstrates that skilled readers are able to generate these elaborate and bridging inferences even when they are dealing with relatively unfamiliar materials (i.e., an expository text about thunderstorm as opposed to narrative texts used in Gates-MacGinitie test). One interpretation of this finding is that skilled readers possess skills/strategies to effortlessly activate relevant information from relatively unfamiliar text-based information (McNamara, in press). This ability is associated with constructive activities such as bridging inferences, and elaborative inferences. Use of these types of strategies, either naturally or after being trained to do so, contributes positively to learning from expository texts.

One limitation of our study is that it focuses solely on the processes readers employ while reading the text, and hence, does not directly show learning gains for skilled readers. However, research supports the assumption that greater use of elaboration is associated with learning gains (Chi, 2000; McNamara, in press).

There are two contrasting views regarding how elaborations contribute to learning: the incomplete text view and the self-repair view (Chi, 2000). These views differ critically with respect to whether (or to
what extent) the accuracy of readers’ elaborations affect learning. In line with Chi’s (2000) view, our assumption here is that elaborations facilitate learning, regardless of whether they are accurate (see also, McNamara, in press). But, of course, we do not rule out the likelihood that there are several different ways in which elaborations can contribute to learning. Accuracy of elaborations may well have important implications for the learning process, particularly when the reader does not have the opportunity to repair inaccurate elaborations based on information encountered later in the text.

In conclusion, the present research highlights the important role active reading strategies play in the comprehension of and learning from expository texts. Given that active strategies are beneficial, future work should explore, in more detail, the reader related factors (e.g., metacognition, knowledge on the strategies, etc) that underlie the use of the strategies, and the text-related factors (e.g., sentence difficulty, that affect active reading.

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References