The Journal of Experimental Education, 2002, *71*(1), 5–23

The Effect of Concept Mapping to Enhance Text Comprehension and Summarization

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ABSTRACT. Although graphic strategies, such as graphic organizers and knowledge maps, have proved helpful for text learning, certain important application issues such as surface processing and cognitive overload have yet to be resolved. The authors tested the learning effects of a concept-mapping strategy. They designed 3 concept-mapping approaches—map correction, scaffold fading, and map generation—to determine their effects on students' text comprehension and summarization abilities. The experimental results from 126 fifth graders showed that the map-correction method enhanced text comprehension and summarization abilities and that the scaffold-fading method facilitated summarization ability.

Key words: concept mapping, graphic strategy, scaffolding

READING STRATEGIES have always been important in teaching- and learning-strategy studies. Among the numerous reading strategies, graphic strategies are one of the few approaches that can be applied at the preview stage before reading, during the reading process itself, and at the stage after reading (Dowhower, 1999). Graphic strategies provide readers with new approaches to reading that are different from traditional, linear text presentation. Instead, the structure of the whole text and the interrelations between concepts are illustrated with a visual method that gives the readers a clearer, more substantial understanding of what is being read (Chimielewski & Dansereau, 1998; Griffin, Malone, & Kamennui, 1995; Robinson, Katayama, & Fan, 1996). Generally speaking, there are three types of spatial learning strategies: graphic organizers (Barron & Schwarz, 1984; Griffin et al., 1995; Katayama & Robinson, 2000), knowledge maps (Chmielewski & Dansereau, 1998; Dansereau & Newbern, 1997), and concept maps (Novak, 1990; Novak & Gowin, 1984).

Despite the differences in visual presentation, these three graphic strategies are very similar in their underlying principles and methods of application. They convert linear textual statements into nonlinear graphic presentations. The tree structure that emerges after the conversion has greater proximity to the macrostructure of the text, making its content easier to retain and retrieve (van Dijk & Kintsch, 1983). Furthermore, the process of developing a graphic organizer is helpful for continued processing of the concepts themselves and the interrelations among them (Armbruster & Anderson, 1984). Applications of both graphic organizers and knowledge maps have achieved impressive results in assisting the reader in memorization and comprehension of text content (Alverman, 1981; Lambiotte, Dansereau, Cross, & Reynolds, 1989; Moore & Readence, 1984; Robinson, Katayama, Bubois, & DeVaney, 1998; Robinson et al., 1996). Although concept mapping is as much a graphic strategy as knowledge maps and graphic organizers, it has been successfully applied primarily to the learning of scientific subjects (Novak & Musonda, 1991; Schmid & Telaro, 1991). A limited amount of research has been conducted on its application to the learning of linguistic content. Thus, our first objective in this study was to explore the effectiveness of concept mapping in enhancing text comprehension.

Although scholars affirm the effectiveness of graphic organizers and knowledge maps when applied to learning, certain important issues from previous studies have yet to be resolved. The first issue involves the use of graphic illustrations provided by experts as a teaching strategy compared with having readers construct a graphic representation by themselves as a learning strategy. The aim of using expert illustrations is to help readers by presenting them with the macrostructure of the text in the form of graphic representations prepared by experts in the subject domain. The readers then have a guide to follow in a top-down approach to reading and finding focus points in the text. This approach saves time that can be devoted to teaching, and a well-defined graphic organization by experts can serve as a preview structure for outlining the text. However, presenting the text outline with an expert's graphic illustration might put the readers in a position in which they only passively take in knowledge from experts with little autonomous learning on their part. This surface processing may even-

This research was supported by a grant from the National Science Council, Republic of China, under contract NSC 89–2614–S–003–003, to the first and second authors.

We are grateful to the teachers and children of Wu-Shin Elementary School for their kind help in this experiment. We also appreciate the reviewers' detailed, concrete, and insightful comments.

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tually undermine their learning performance (Barron & Schwarz, 1984; Griffin et al., 1995; McCagg & Dansereau, 1991). In contrast, graphic organization construction by the readers themselves is effective in promoting autonomous learning and enhancing the depth of learning, but the required training of students is time consuming. Moreover, the activity demands effort and usually results in cognitive overload and negatively affect learning outcomes (Chang, Sung, & Chen, 2001; Katayama & Robinson, 2000) and even the willingness to use this strategy.

Using experts' graphic presentation may reduce the teacher's workload and result in little autonomous learning, whereas having readers construct a graphic presentation may foster deeper processing but cause cognitive overload. In this study, we proposed two approaches to solve this dilemma. One feasible method is to combine scaffolding instruction with spatial learning strategies. *Scaffolding instruction* is a teaching method that provides differing degrees of assistance for a learner according to his or her progress. As the learner's abilities grow, the assistance formerly available is gradually withdrawn until he or she can learn independently (Day & Cordon, 1993; Day, Cordon, & Kerwin, 1989). Previous studies have found that scaffolding instruction enhances the student's learning ability and the degree of knowledge transfer (Day & Cordon, 1993; Kao & Lehman, 1997). The expert map is used at the beginning as a kind of scaffold that helps readers learn the text; as readers attain higher levels of performance, the content of concept maps provided by the experts declines. The more complete expert maps are gradually replaced by less complete maps (e.g., a partially blanked map or a skeletal map with concept list). In the end, students must find relevant concept nodes and relations to construct a map on their own. Beginners are given assistance in constructing concept maps in the earlier stages; learners in more advanced stages are allowed to use their newly acquired strategies independently and process the learning material in deeper, more idiosyncratic ways.

Another possible solution for overcoming the surface processing and overload problems derives from the spirit of the *completion strategy* proposed by van Merrienboer (1990; Chang, Chiao, Hsiao, & Chen, 2000; Sweller, van Merrienboer, & Paas, 1998). According to that strategy, the learner should work on completion problems; in those problems, a given state, a goal state, and a partial solution are provided to learners who must complete the partial solution. The completion problems may also be viewed as a bridge between providing a complete solution, which may not engage the learner, and not providing any hints, which may result in cognitive overload during the problem-solving process (Sweller et al., 1998). For concept mapping, presenting an expert map is somewhat like giving a complete solution to learners, whereas constructing a map may be viewed as a goal-oriented, problem-solving task without assistance.

To bridge the gap between reading expert maps and constructing maps, we propose a *map-correction* approach. With this method, the learner uses an expert map with about 40% of the concept nodes or their interrelations incorrect according to the text content. Such an approach combines the strong points of having learners read an expert map and having them generate a map, because the valid structure of the expert map may serve as a framework for text content and map construction, thereby facilitating text comprehension and reducing the workload of constructing a map. In contrast, to detect and correct the partially incorrect nodes and links in the expert map, learners not only have to read the entire structure of a given map but must also think critically about what is wrong with the map. By referring carefully to the text and then selecting the appropriate concepts and relations for the map, students avoid the potential problem of surface processing. Such an approach is similar to that used in some previous studies that used a partial graphic organizer to engage student note taking (Katayama & Robinson, 2000). Our second objective in this study was to compare the three concept-mapping strategies for text learning—scaffold fading, map correction, and map generation—to determine how students can most effectively learn from concept mapping.

The second problem in the application of graphic strategies is that most past findings were based on comparisons of evaluation results obtained immediately after the training was finished (Moore & Readence, 1984). This approach may be good for examining the immediate influences of graphic strategies on text learning, but it says little about what happens afterward. Does the assisted reading effect disappear right away when expert maps no longer accompany the text or readers are no longer asked to use graphic strategies? Moreover, most studies on graphic strategies use text retention and comprehension as their dependent variables. Whether the acquisition of mapping strategies enhances other reading skills, such as the ability to summarize, has yet to be explored. The procedures emphasized in summarization training—selection of a topic sentence, trivia and redundancy deletion, detail integration, and superordination of lists (Brown & Day, 1983)—are strikingly similar to the procedures emphasized in the concept-mapping process: the selection, propositionalization, hierarchicalization, and structuralization of key concepts. Therefore, at least theoretically, training in concept mapping should be beneficial for enhancing summarization skills. Chmielewski and Dansereau (1998) found that the knowledge-map strategy could be effectively transferred to situations in which students are not asked to use strategies. Whether this technique also helps enhance summarizing skill has not yet been examined. Therefore, our third objective in this study was to extend and expand on the Chmielewski and Dansereau study to determine whether the concept-mapping training effect can be transferred to posttraining situations in which using this strategy is not required and whether this transfer also applies to summarization capabilities.

Method

Participants

The participants were 126 fifth-grade students from four classes in an elementary school in Taipei, Taiwan. The group included 60 girls and 66 boys. The four classes were randomly assigned intact to three experimental groups and one control group. The four groups contained 26, 32, 34, and 34 students, respectively.

Design

The study involved 7 weeks of reading, map-construction instruction, or both for the experimental and control groups, as well as pre- and posttests in text comprehension and summarization. The design involved one between-subjects factor group. There was one control group and three experimental groups, namely, the map-correction, scaffold-fading, and map-generation groups. The dependent measures included a comprehension score and a summarization score. The pretest measures of comprehension and summarization served as covariates.

Measures

Pre- and posttest text comprehension tests. We adopted the Expository Text Comprehension Test (Lin & Su, 1991) as a pretest tool to evaluate students' initial text comprehension abilities. This test includes five pieces of expository writing from both scientific and social science domains; each article includes between 200 and 400 Chinese characters. Twenty-five multiple-choice questions were constructed from those articles. The students scored 4 points for each correct answer. The Kuder–Richardson reliability was .86, and the pretest–posttest reliability was .77, with responses from 120 fifth graders. To avoid the possible practice effect from using the same tool for the posttest, we constructed another 20-item multiple-choice text comprehension test from an article of 850 Chinese characters titled "Barrier of the Earth." The students earned 5 points for each correct answer on this test. The split-half and KR20 reliability coefficients from 116 fifth graders were .80 and .78, respectively. One item was deleted after the item analysis procedure, resulting in a 19-item posttest. The items were classified into two different types: (a) text-based questions for which the necessary information was stated in the original text (n = 15) and (b) inference questions that required some type of inferencing to link information from separate sentences or paragraphs (n = 4).

Pre- and postsummarization tests. To evaluate student initial summarization ability, we used as reading material an article titled "Knowing Typhoons," which consisted of 689 Chinese characters. The results were expressed in terms of *summarization efficiency* (i.e., the number of major idea units in the summary divided by the total word count of the summary) as proposed by Garner (1982). Summarization efficiency scores ranged from 0 to 1; the fewer words used to represent the main ideas of the article, the higher the summarization efficiency. We used summarization efficiency of the article "Barrier of the Earth" to compare experimental results. Two fifth-grade teachers were invited to rewrite the two articles to make certain that they were suitable for fifth graders. The teachers also collaboratively wrote summaries of the two articles, extracted the main idea units (20 and 24 idea units were extracted, respectively, which corresponds roughly to the major clauses of the sentences in the summary) and constructed an expert map for the "Barrier of the Earth" article.

Instructional Materials

In this study, we used seven pieces of scientific writing (see Table 1). Each article consisted of 400 to 820 Chinese characters. The students were given a concept-mapping training course consisting of seven units corresponding to these articles. We consulted with two elementary school science teachers in selecting and rewriting the articles and producing expert concept maps.

The three experimental groups used the same articles for reading materials, but each received a different map-construction exercise. The map-correction group was given an expert-generated concept map that was partly revised to contain incorrect concepts and semantic links (the incorrect content accounted for some 30–40% of the revised expert-generated maps; see Figure 1). The readers had to finish reading the text before they could correct the erroneous concepts and semantic links. During the correction process, they could press the "scoring" button to see how well they were doing with their corrections. The window under the button showed the percentage of right corrections (we set the maximum number of feedbacks at 5 for each article to avoid using a trial-and-error procedure). The scaffold-fading group was given a seven-unit training course. Their map-construction procedures were based on the 3D scaffolding instruction model by Kao and Lehman (1997). The reading materials for this experiment were arranged into five stages: (a) read an expert concept map, (b) fill in the blanks of the expert concept map (with whole structure), (c) complete the partial expert concept map (with partial structure), (d) construct the concept map using the given concepts and relation links, and (e) determine the key concepts and relation links from the text to construct the concept map. The scaffolds provided at each stage and the corresponding learning activities are shown in Table 1 and Figures 2a–e. For the map-generation group, only the articles were provided. When the participants finished reading, they extracted concepts and semantic links from the text to construct the concept maps for the articles by themselves (which is like the last stage of the scaffolding group).

We used the Concept Mapping Learning System (Chang et al., 2001; Sung, Chen, Lin, & Chang, 1998) to conduct the text presentation and the concept-

TABLE 1
Learning Units, Unit Activities, and Corresponding Degree of Scaffolding for the Scaffold-Fading Group

Unit title	Unit activities	Forms of scaffold provided
Unit 1: The blood	Read the complete expert-generated concept map.	1. Complete expert-generated concept map
Unit 2: Does photosynthesis happen in red leaves?	Fill in the blanks in the concept map according to the concept list and semantic link list.	1. Complete expert-generated concept map with 30% of the content blanked out 2. Concept list 3. Semantic link list
Unit 3: Does a broken light bulb light up?	Fill in the blanks in the scaffolding map according to the concept array and semantic link array and complete the missing concepts and semantic links.	1. Incomplete expert-generated map that requires readers' supplementation 2. Concept list 3. Semantic link list
Unit 4: Tides	No map is provided. The reader builds the concept map according to the concept list and semantic list.	1. Concept list 2. Semantic link list
Unit 5: Knowing typhoons	No map is provided. The reader builds the concept map using the partial concept list and semantic list, as well as concepts and semantic links found in the text by the reader.	1. Incomplete concept list and incomplete semantic link list
Unit 6: The eyes	The reader finds concepts and semantic links independently to build concept map.	1. Only the text itself
Unit 7: Mushrooms	The reader finds concepts and semantic links independently to build concept map.	1. Only the text itself

mapping exercise. The system provides various kinds of feedback according to different concept-mapping procedures. The map-correction group received the percentage of their right corrections (compared with the expert map) as feedback. The map-generation group received the percentage of their correct selections of key concepts and links (compared with the key concept list) and the N–G score, an indicator of the completeness of a concept map derived from Novak and Gowin's (1984) scoring rubric. The scaffold-fading group received the percentage of correctly filled blanks and the same feedback that was provided to the generation group.

Procedure

General orientation and pretest. One week before the experiment, the concept-mapping methods and their corresponding operational procedures for the com-

FIGURE 1. An example of a partially incorrect map for the map-correction group.

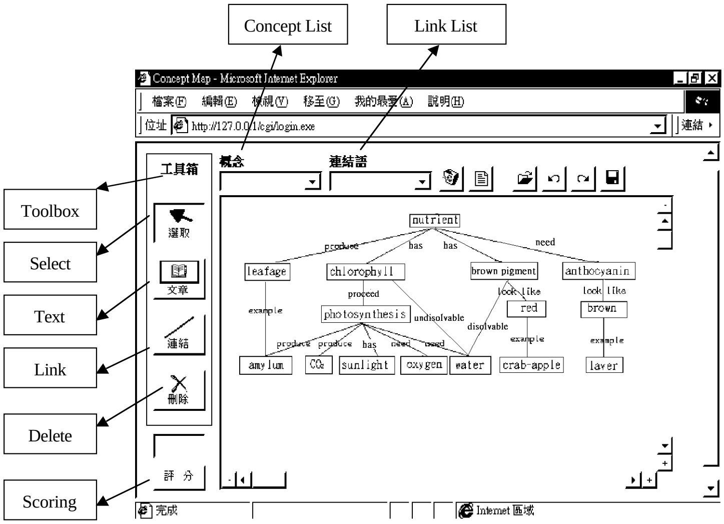


FIGURE 2a. An example of the expert map for the scaffold-fading group.

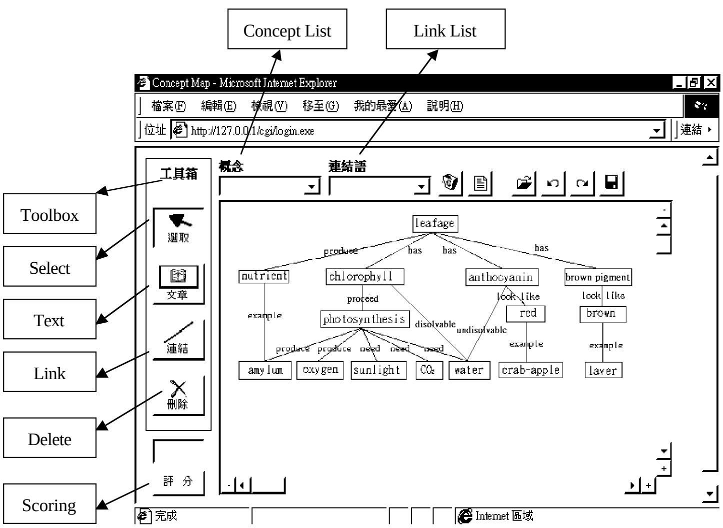


FIGURE 2b. An example of the map with partial blanks for the scaffold-fading group.

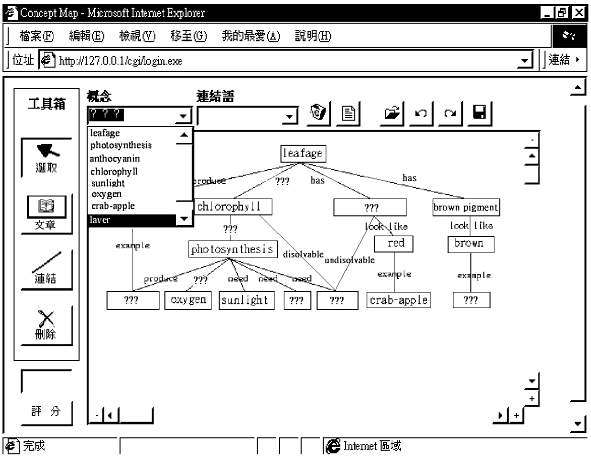


FIGURE 2c. An example of the map with partial structure for the scaffold-fading group.

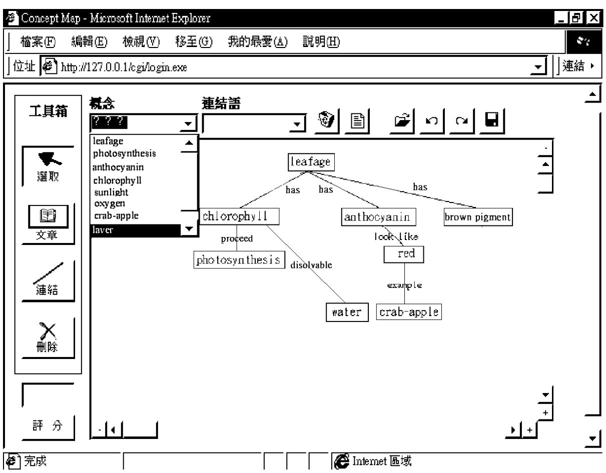


FIGURE 2d. An example of constructing the map from the concept list and the link list for the scaffold-fading group.

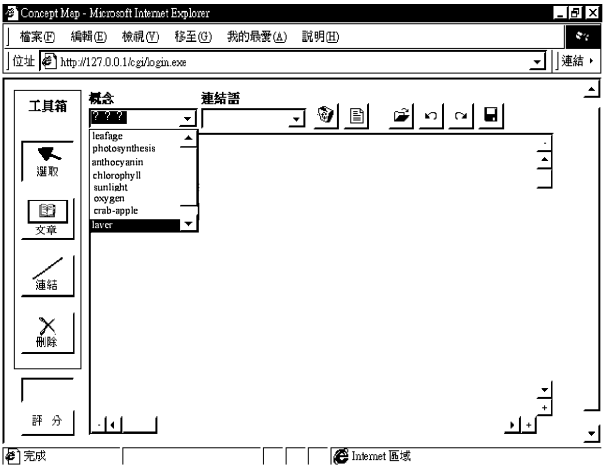
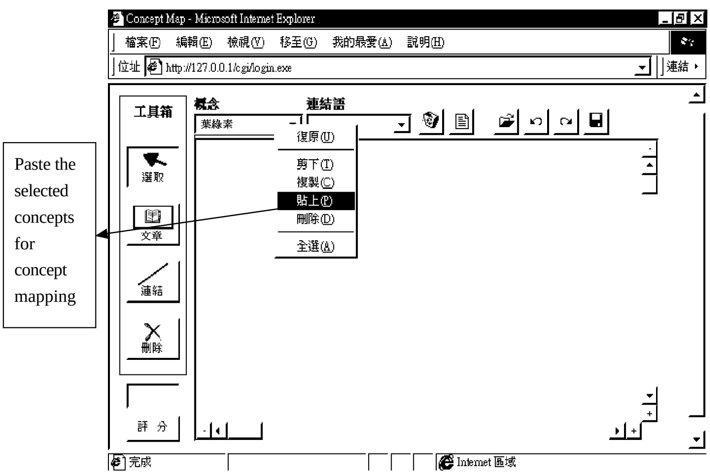


FIGURE 2e. An example of selecting key concepts and links from the text for the scaffold-fading and map-generation groups.



puter-based system were explained to the participants in the three experimental groups. The control group was instructed on how to read the texts presented in Microsoft Word. The term “summarizing a text” was also explained to the students. One article titled “The Greenhouse Effect” was used for practice; this phase took about 2 hr. The day after the orientation course, all of the participants took the expository text comprehension and summarization pretests. The two tests took 20 and 25 min, respectively. The participants were allowed to spend 12 min reading the text and 12 min summarizing the text.

Formal experiment. The participants worked individually with a computer to read the texts, construct concept maps about the contents of the lesson, or both. Each session took approximately 40 min. During each session, the participants were asked to read the text for about 10 min and then construct or correct their concept maps. During the map construction process, the experimental groups could refer to the text and revise their maps according to the evaluation feedback provided by the system. The participants in the control group simply read the article provided for the experiment stage that they were in. These training sessions were held twice per week and lasted for 4 weeks.

Posttest. The posttest was carried out 1 week after the course was completed. The participants were asked to read the text for 15 min and then summarize the contents for 15 min. The students were allowed to refer to the text during their summarizing. They then took a text comprehension test that lasted for 20 min. When the students read the posttest text, they were not asked or reminded to use the strategies that they had been taught during the previous weeks. After the posttest, the students responded to a questionnaire about their views on the operational difficulty, usefulness, and affective acceptance of concept mapping.

Results

Concept Mapping as a Graphic Strategy for Text Comprehension

The students’ pre- and posttests of text comprehension and summarization scores are shown in Table 2. We used a one-way analysis of covariance (ANCOVA) in which the pretest text comprehension scores of the four groups were the covariates and their posttest scores were the dependent variables. The results (Table 3) indicated that the test of heterogeneity of regression slopes was not significant, $F(3, 118) = 1.02$, $p > .05$, and the effect of group was significant, $F(3, 121) = 4.40$, $p < .01$. The four groups achieved conspicuously different scores, with the influence of pretest scores excluded, in the reading comprehension posttest. A post hoc comparison using the Bonferroni method showed that the map-correction group did better on the posttest than the map-generation group and the control group did, and the differences in posttest scores among the scaffold-fading, map-generation, and control groups were not significant. The map-

TABLE 2
Means and Standard Deviations of the Pre- and Posttests of Text Comprehension Summarization Abilities

		Abilities							
		Comprehension				Summarization			
		Pretest		Posttest		Pretest		Posttest	
Group	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Correction	26	53.04	14.70	79.16	13.83	.0369	.0141	.0573	.0173
Scaffolding	32	54.53	14.10	71.41	13.03	.0384	.0144	.0500	.0114
Generation	34	56.47	14.08	69.42	13.13	.0415	.0176	.0447	.0171
Control	34	54.62	12.16	66.58	15.61	.0432	.0132	.0403	.0124

TABLE 3
Analysis of Covariance in Summarizing Efficiency Scores

Source of variance	*SS*	*df*	*MS*	*F*
Group	2,906.204	3	968.73	6.25*
Within groups (errors)	18,756.63	121	193.9	
Group × Covariates	445.83	3	148.61	.96
Within + residual	18,310.80	118	155.18	

*$p < .05$.

correction strategy worked significantly better for improving the reading comprehension of elementary school students than the scaffold-fading and map-generation methods of concept-mapping or not using concept-mapping strategies at all.

Concept Mapping for Enhancing Text Summarization

To determine the effects of concept-mapping methods on facilitating a learner's summarization ability, we divided student summarization protocols into idea units (roughly corresponding to the major clauses of the sentences in the summary), and two student raters then compared them with the idea units of teachers' summaries. The initial interrater reliability was .87. Any inconsistency was resolved by further negotiation. We then submitted the counts of students' valid idea units (which should be at least roughly consistent in meaning with teachers' idea units) to the summarization efficiency formula (Garner, 1982) to produce an indicator of the student's summarization ability. The number of students' valid idea units ranged from 3 to 16. The number of Chinese characters used in the written summaries ranged from 121 to 275. The efficiency indicator ranged from .02 to .08. The means and standard deviations of the pre- and posttest efficiency scores are shown in Table 2.

We conducted a one-way ANCOVA in which the summary efficiency scores in the pretest were the covariates and the posttest efficiency scores were the dependent variable. The test of heterogeneity of regression slopes was not significant, $F(3, 118) = 2.44$, $p > .05$, and the effect of group was significant, $F(3, 121) = 11.85$, $p < .01$ (see Table 4). The post hoc comparison using the Bonferroni method revealed that the map-correction group achieved better scores in the summary posttest than the map-generation and control groups did. The scaffold-fading group fared better in the summary posttest than the control group did. The scores on the summary posttest for the map-generation and control groups did not demonstrate any significant difference. The map-correction strategy had a significantly greater influence on the participants' text summarization ability than did the map-generation method or not using any concept-mapping strategy. The scaffold-fading strategy, in turn, was superior to no concept-mapping strategy for enhancing the participants' text summarization ability. Finally, the text generation abilities of students using the map-generation method were not significantly different from those of students who used no concept-mapping strategy.

Discussion

Concept Mapping as a Graphic Strategy for Enhancing Text Comprehension

In this study, we adopted three different concept-mapping methods—map correction, scaffold fading, and map generation—to improve learners' text comprehension. The map-correction group demonstrated more improvement in text comprehension than the map-generation and control groups did. The map-correction procedure involved using the concept map to form the content framework of the article being read. Such a framework functions as a structure to demonstrate the content and serves as a reminder of the gist of the text and the linking

TABLE 4
Analysis of Covariance in Summarizing Efficiency Scores

Source of variance	*SS*	*df*	*MS*	*F*
Group	0.01	3	0.0033	11.85*
Within groups (errors)	0.02	121	0.0002	
Group × Covariates	.0012	3	.0004	2.44
Within + residual	.02	118	.00017	

*$p < .05$.

between ideas (Alverman, 1981; Moore & Readence, 1984). Moreover, constructing an expert map by correcting misplaced concept nodes and links not only preserves the advantages of providing an expert knowledge structure but also corrects possible negligence (McCagg & Dansereau, 1991) and passive knowledge acceptance (Barron & Schwartz, 1984; Katamaya & Robinson, 2000) of readers in reading expert maps.

Using Concept Mapping to Enhance Summarization Ability

Chmielewski and Dansereau (1998) found that the increased reading comprehension brought about by knowledge maps was not limited to situations in which the knowledge map and the corresponding article appeared simultaneously. When readers read different material at different times, they were able to apply the knowledge-map strategy that they had previously acquired to assist them with comprehending and memorizing the present article. In our questionnaire about using concept mapping, about 79% of students in the map-correction and scaffold-fading groups reported that they remembered using concept mapping during their reading and summarizing posttests. In addition to verifying once again the discovery of Chmielewski and Dansereau that a graphic strategy can be applied in a different context (1 week after training), we found that concept-mapping training may effectively transfer to text summarization skills that are closely tied to comprehension. Furthermore, both the map-correction and scaffold-fading groups achieved better results in summarization enhancement than the control group did. This finding has two implications. First, adopting concept mapping as a graphic strategy not only brings about continuing effect for other materials but also assists in situations in which readers are not specifically required to apply concept-mapping skills. That is, the training effect is retained for a certain period of time. Second, concept-mapping strategy training not only improves reading comprehension skills but also benefits other linguistic skills related to comprehension, such as text summarization skills. The reason for this might be that the processes of these two activities have much in common. Concept mapping emphasizes the selection of major ideas (key words), connecting and organizing these concepts using relation links, and finally presenting the major framework of the article. There is an obvious overlap between this process and text summarization as proposed by Brown and Day (1983). Because of the similarity in the operations, it makes sense that the learning effects of the concept mapping strategy can transfer to summarization skills.

Another noteworthy phenomenon is that although the scaffold-fading group scored higher than the control group in text comprehension, this difference was not significant. In contrast, the scaffold-fading group scored much higher in summarization efficiency than the control group. It appears that the effects of training with the scaffold-fading method were revealed only through their summarizing ability. Brown and Day (1983) found that most fifth graders were already able to correctly delete unimportant or redundant messages in an article, which means that they might be able to grasp the main ideas of an article. That ability might have greatly helped the readers answer text-comprehension test questions appearing in a recognition format in our study, which is a simpler task than text summarization. In the text summarization task, in addition to grasping the gist and effectively deleting unimportant messages, readers were also required to compile and reorganize the main ideas, which is much more difficult than answering multiple-choice questions. This might be the reason that the training effects of scaffold-fading learning were more apparent for text-summarization skills than for text comprehension.

Different Ways of Using Concept Mapping

To seek more appropriate ways of using concept mapping, we designed three concept-mapping methods with varying degrees of scaffolding support, namely, map construction by correction (with constant and highest degree of scaffolding), by scaffold fading (with gradually removed scaffolding), and by generation (with the least scaffolding).

Our finding that the map-generation group did not fare better than the control group was not new. Reader and Hammond (1994) found that even college students had difficulty in constructing and revising a concept map. Chang, Sung, and Chen (2001) found that for juniors who were provided with the same feedback and guidance as in this study, few learning effects could be detected. In a similar study, Kiewra, Dubois, Christensen, Kim, and Lindberg (1989) found that using a skeletal graphic organizer was not as effective as using outlines or conventional notes. Kiewra et al. suggested that learners used a high level of attention to complete a skeletal framework and that few resources were left for understanding. Thus, cognitive load seems to be the major reason for the low benefits derived from a self-generating approach to graphic strategies.

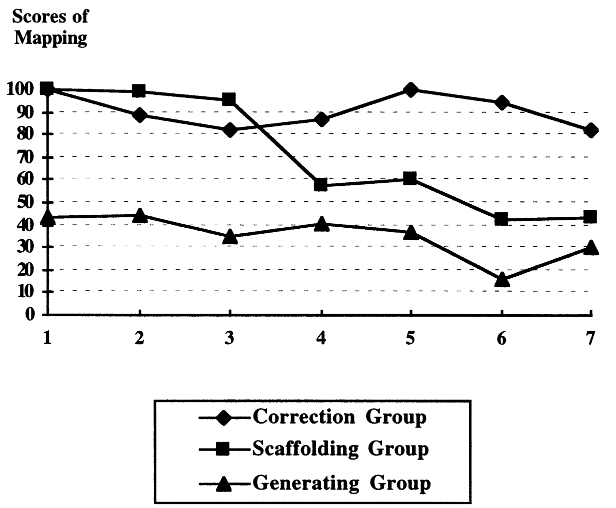
In contrast to the students in the map-generation method, those in the map-correction method outperformed the control group on both comprehension and summarization performance. The framework and partial information provided by the map correction procedure seems to be a more suitable way for conducting concept mapping for elementary students. Katayama and Robinson (2000) indicated that a partial graphic organizer functioned better than a skeletal graphic organizer owing to less overload, more engaged participation, and more encoding process provided by the partial graphic organizer. The superior effects of the map-correction procedure over map generation provided converging evidence for their findings. By asking a learner to correct concepts and links in the partially incorrect expert map, the researchers forced them (a) to fully “encode” and understand the concepts and the connections between them from the entire map and (b) to use critical and analytical thinking to detect the improper relationships between concepts.

From the findings that the scaffolding group outperformed the map generation and control groups only on text summarization, we can see that the hypothesis that learning by scaffolding achieves better learning results was only partially supported. This finding is not entirely consistent with that of Day and Cordon (1993) and Kao (1996) that the scaffolding instruction method had better direct and transferring effects than general teaching methods that do not provide gradual scaffolding support and removal. We found that the effect of scaffolding concept mapping conducted with a gradual graphic adjunct removal was not superior to the strategy without gradual removal. There are several possible explanations for this. First, the operations performed after the scaffolding was removed may still have been too difficult for elementary school students. During the experiment, students from both the scaffold-fading group and the map-generation group mentioned to the researcher that concept mapping was not an easy task. They expressed the same opinion in the questionnaires administered after the experiment. Also, seen from the scores of the three groups in the comparison of their concept maps and expert maps (as shown in Figure 3), the scaffold-fading group scored at a level similar to that of the map-generation group after Unit 4 (from which students should find the key concepts and links and generate concept maps by themselves). The scaffold-fading group's accuracy scores were only about half those of the map-correction group. That result shows that once the scaffold was removed, these schoolchildren still had difficulty achieving the desired learning effect in constructing concept maps, although they had received four units of training.

Another reason that the learning effect of mapping by scaffolding and by map generation in this study was not fully realized may have been the lack of sufficient time for training. Bean, Sorter, Singer, and Frazee (1986) argued that it took 14 weeks to learn an assistance strategy to demonstrate results, and it took as long as a year of using the strategy to completely internalize the learning. In the 6-week training of this study, even though the scaffold-fading instruction design emphasized proper scaffold removal procedures and feedback provisions, the length of the overall training period might not have been sufficient for elementary school children. Therefore, the full effect of strategies that were more complicated and required more mental effort, like map generation, were not demonstrated. On the other hand, the results were much more apparent when the map-correction method was used because it was easier and the learners were more capable of using it. If we can prolong the training and refine the feedback procedure, the results of training should improve.

Many of the attempts by past researchers to use graphic strategies such as knowledge maps and graphic organizers to improve reading comprehension have reaped positive results (Chmielewski & Danserau, 1998; Griffin, Malone, & Kameenui, 1995; Robinson et al., 1996). In addition to continuing relevant inves-

FIGURE 3. Concept map scores of the experimental groups in various units.



tigations on graphic strategies for reading improvement, this study is different from past studies in three ways. First, the concept map was adopted as the graphic strategy, and the actual effects of applying such a strategy were tested. Such an approach has been widely used in science education, but less often in text learning. Second, we modified the way in which concept mapping was used. The principles of scaffolding instruction and completion strategy were used along with traditional methods of map presentation and generation. Third, we examined both the text comprehension and text summarization abilities of learners who had used concept mapping as a graphic strategy. We believe this study will stimulate further research and thinking about the use of reading strategies.

The findings demonstrate that concept mapping may serve as a useful graphic strategy for improving text learning. The findings also suggest that combining a spatial learning strategy with a correction method or scaffolding instruction is a potential approach for optimizing the effects of concept-mapping. Further explorations using longer training duration and more extensive reading materials along with participants of different levels of reading abilities are worth considering to verify the relative efficiency of different concept-mapping methods for enhancing text learning.

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