Effects of Teaching Text Structure in Science Text Reading:

A Study Among Chinese Middle School Students

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Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2019

ABSTRACT

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The purpose of this study was to determine whether teaching students about the structure of a text would be associated with improved reading comprehension. Science texts were used with the intention of adding to what is known about content-area reading comprehension. To investigate the effects of teaching science text structure, a reading comprehension program called Comprehending Science Texts with Structure (CSTS) was developed and tested using an true experimental design. Importantly, the study was conducted in China with Mandarin-speaking students, with whom there has been a great shortage of reading research. The CSTS program is a 15-lesson reading comprehension program designed to teach middle school students how to comprehend science texts by using three text structure strategies, namely asking generic questions (GQs), using graphic organizers (GOs), and summary writing (SW). A total of 88 sixth grade students participated in this study and were randomly assigned to either the CSTS intervention group or the content-only control group. After the completion of the CSTS program, students' text structure knowledge and reading comprehension were measured using researcher-designed measures of the comprehension of both science and generic text. The generic text was used in order to investigate near-transfer effects. Far transfer was measured post-intervention through the use of two standardized reading tests, one taken from a state assessment and the other from the PISA reading test. Results from multivariate analyses of covariance indicated that, overall, students in the treatment group significantly outperformed their counterparts in the control group after controlling for pretest reading skill and science knowledge. Specifically,

students who received the CSTS intervention showed significant acquisition of science texts structure knowledge and also significantly outperformed the controls in the comprehension of science texts. The results also demonstrated the near-transfer effects of the CSTS from science texts to generic texts; here, students in the treatment group significantly gained generic text structure knowledge and also significantly outperformed the controls in the comprehension of generic texts significant. A far-transfer effect, however, was not found, as the two groups did not show a statistically significant difference in performance on the post-test standardized reading comprehension tests.

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ACKNOWLEDGMENTS

This work is dedicated to my daughter, Cecilia Xingxing Xu.

CHAPTER I

INTRODUCTION

The effective learning of science requires sophisticated reading and writing skills. These skills include the ability to understand scientific terminology, interpret data, comprehend scientific texts, and to read and write scientific explanations (Greenleaf et al., 2011; Norris & Phillips, 2003). However, many students find it extremely difficult to read science texts, as their content conveys new knowledge about scientific concepts involving complex mechanisms with multiple components, attributes of components, and relationships among different components (Otero, Leon, & Graesser, 2014). As a result, students with little background knowledge of science or limited reading skills often encounter difficulties in reading scientific texts (Fang et al., 2008; Greenleaf et al., 2011; Lien, 2009).

During the last several decades, experts have called for continuing development of instruction that integrates both science and reading. To help students develop proficient literacy skills, reading researchers have suggested that adolescents need support when they are interacting with dense and complex texts (Snow & Biancarosa, 2003). Furthermore, science educators have been emphasizing the need to bridge the gap between literacy practices and the teaching and learning of science in the classroom in order to help students develop into scientifically literate citizens. Therefore, there is an urgent need for educators to design interventions that emphasize both science content and associated reading skills in order to enhance students' science learning ability (Norris & Phillips, 2003; Wellington & Osborne, 2001; Yore, Hand, Goldman, & Hildebrand, 2004).

Reading Science Texts: Challenges for Middle School Students

Middle school students' exposure to expository text, particularly in the fields of social studies and science, increases dramatically at this stage. According to Moss (2005), 50% of the test content of the National Assessment of Educational Progress (Grigg, Daane, Jin, & Campbell, 2003), which assesses students' academic achievement at 4th, 8th and 12th grade, requires students to read expository texts at 4th grade. This percentage further increases to 73% by the 8th grade.

In addition to the increased exposure of expository texts, another major change that occurs at this stage is that students start to use reading as a tool for acquiring new knowledge. Specifically, texts begin to feature concepts and vocabulary beyond those reflected in students' native tongue or their life experience. Therefore, in order to read, understand, and learn from more demanding texts, students must expand their vocabulary and content knowledge base and strengthen their ability to think critically and broadly (Chall & Jacobs, 2003). However, the teaching of required reading strategies (such as critical reading and content area vocabulary) is intertwined within content instruction. As a result, it can be challenging for middle school students who do not necessarily have sufficient reading proficiency to comprehend texts.

Despite the increase in both the difficulty and the required amount of reading for middle school students, only a limited amount of explicit reading instruction is provided to students at this level (Fang & Wei, 2010). In the current middle school setting, teachers usually identify with their content domains of science, math, history, or English (Guthrie & Davis, 2003). As they tend to focus on content coverage, teachers find themselves lacking not only in time and support but also the knowledge and skills required to teach reading-related skills in their classes (O'Brien, Stewart, & Moje, 1995; Yore, 1991). Consequently, students who are unable to effectively utilize multiple strategies to navigate texts may find the reading expectations in middle school daunting. As a result, in the absence of explicit instruction, many middle school students lack the support

that is needed to incorporate reading comprehension strategies as they navigate scientific texts, resulting in deficits in their foundational knowledge of the subject matter. Therefore, middle school teachers must expand their instruction to incorporate both the application of reading comprehension skills and the teaching of content specific information.

Reading Activities for Native Mandarin Speakers in Mainland China

Just as in English-dominant educational settings, reading plays a crucial role in the Chinese education system. For example, researchers have noted that Chinese language arts classes place a strong emphasis on reading skills (J. Zhang, 2013). However, research data also indicates that reading performance on the part of high school graduates remains unsatisfactory and that students' reading comprehension skills are in urgent need of improvement (Zhao, 2011; Hunan Provincial Education Examination Board, 2012). Zhao (2011) investigated the performance of Chinese students in the subtest of reading comprehension in China's National Higher Education Entrance Exam, also known as Gaokao, which is the most important exam developed by the central government and administered annually at the end of each academic year to high school seniors. It was found that students only scored an average proficiency of 50% in this test. A similar study analyzing the 2012 results of the Gaokao in Human Province also found a proficiency rate of only 49.04% (Hunan Provincial Education Examination Board, 2012). These findings emphasize the urgent need to improve reading instruction for Chinese students.

Possible reasons for the low reading proficiency rates on the part of Chinese students may vary by context, yet the strongest areas of concern seem to be a lack of prior knowledge of academic content and ineffective use of reading strategies to interpret the meaning of a text (Lau & Chan, 2007). It has been noted that Chinese language arts classes in Mainland China place a strong emphasis on vocabulary instruction and rote learning of content, but devote relatively

little attention to rhetorical analysis of the text (Lau & Chan, 2007). Moreover, a lack of reading practice in a subject domain, especially in that of science, is also an important issue (Liang & Shen, 2006). Ma (2011) indicated that teachers rely heavily on science textbooks, most of which feature graphic illustrations and simple explanations of science concepts. Therefore, students have few opportunities to read authentic science materials in their science classes, resulting in a lack of reading practice in subject area instruction, especially in science. Incorporating reading comprehension instruction that focuses on comprehension strategies, such as text structure, and authentic texts that focus on content will benefit students attending schools in Mainland China.

The need to develop reading skills that can be applied to various types of texts, especially the science texts, has also been addressed in the New Curriculum Standard of Yuwen (language and literature), a nationwide guideline published by the Ministry of Education of China in 2011(Ministry of Education of China, 2011). The New Curriculum recommends that students who are transitioning from elementary to secondary school should be exposed to more informational and scientific texts and should also acquire reading skills in text structure, including but not limited to how to analyze and identify important information from those texts. All of these requirements demonstrate the importance of investigating the effectiveness of reading instruction at the middle school-level for native speakers of Mandarin, especially the effectiveness of teaching students about the structure of science texts in middle schools.

Text Structure

Text structure instruction involves teaching students how to identify different types of expository texts, namely cause-effect, compare-contrast, problem-solution, sequence and description. It has been found to be a key reading intervention that can effectively support students in processing complex expository text in content areas such as science (Meyer & Poon,

2001; Williams et al., 2016; Williams, Stafford, & Lauer, 2009). There is ample empirical

evidence indicating that instruction in the text structure of expository texts improves reading

comprehension in both the school years and beyond (Snow, 2002). Studies have indicated that

students with high sensitivity to the text structure of expository texts demonstrate better

outcomes in reading comprehension (Williams et al., 2009). For example, Williams and her

colleagues found that second-grade students significantly improved their reading ability after

being taught text structure strategies within the context of science and social studies (Williams et

al., 2006; Williams et al., 2016). In addition, based on a recently developed comprehensive

model of the cognitive skills that support reading comprehension, researchers have proposed that

the ability to plan and organize information by identifying text structure is essential to successful

reading (Eason, Goldberg, & Young, 2012).

As stated previously, empirical evidence from prior studies demonstrates the

effectiveness of learning text structure in terms of improving students' reading ability. However,

the value of text structure instruction in specific content areas, particularly science, has not been

fully examined. The effectiveness of explicit instruction could vary depending on the grade and

reading levels and the cognitive abilities of the students (Spence, Yore, & Williams, 1999).

Studies reported that students experience challenges in transferring text structure knowledge to

new content areas (Pearson, Moje, & Greenleaf, 2010; Spence, Yore, & Williams, 1999). These

findings suggest that there is still much to be learned about the effectiveness of text structure

instruction, as well as the relationship between the use of text structure strategies and science

reading proficiency, among specific student groups.

Based on challenges identified above, this research aims to evaluate the potential

effectiveness of text structure instruction, particularly as relates to the comprehension of science

text. This dissertation first presents the findings of a pilot study, followed by the statement of the purpose and the research question of the main study. Thereafter, as a basis for the studies, this dissertation reviews previous studies on the topic of text structure instruction, reading instruction in science, and reading instruction conducted in Mandarin. It also discusses the gap between the findings of previous research and the needs of students. The methods employed in the study are then described. Finally, the paper presents and discusses the results of the main study.

The Pilot Study

Evidence from previous studies has demonstrated the effectiveness of teaching text structure to students ranging from the elementary school to the college level. However, there are still unanswered questions regarding the effectiveness of teaching text structure. In particularly, there are only a limited number of studies that have focused on the domains of science, for middle school students, and native Mandarin speakers. To obtain a better understanding of and to develop superior strategies for enhancing science reading in Mandarin-language settings, the researcher developed an approach to reading instruction that focuses on the comprehension of science texts for middle school students who are native Mandarin speakers was developed and conducted a pilot study to investigate its effects.

A reading instruction titled the Comprehending Science Text within Structure for Chinese middle school students was developed. This instruction focused on two areas: 1) how to identify five basic types of structure (sequence, description, causation, compare-contrast and problem-solution), and 2) how to use the knowledge of the text structure to extract important information from a the text. By teaching students crucial reading strategies including the use of Generic Questions (GQ), Graphic Organizer and Summary Writing (SW), the study examined whether the employing these strategies can help students improve their reading comprehension

of science texts.

In addition to examining the effects of text structure on science texts, the study is also interested in the transfer effects of text structure instruction. Previous research has demonstrated the importance of investigating the effectiveness of transfer measures on instruction. The findings suggested that this effectiveness can be measured on a continuum ranging from near transfer to far transfer across domains such as the knowledge domain, temporal context, and modality (Barnett & Ceci, 2002; Hebert, Bohaty, Nelson, & Brown, 2016). Therefore, the pilot study investigated the effectiveness of two domains of the transfer. The first domain is the near-transfer of knowledge domain, which is evaluated by investigating the effectiveness of the CSTS instruction on generic texts. The second domain is the far-transfer across the knowledge domain and modality, which is usually referred as general reading comprehension based upon norm-reference tests.

Research Questions. Specifically, the pilot study investigated whether explicit instruction of text structure within science content helps native Mandarin speaking middle school students improve reading comprehension in the following three areas:

1. Comprehension of science texts;

2. Comprehension of generic texts (not specific to science texts);

3. Reading comprehension in general.

Method. *Participants.* One eighth-grade class from a public school in Shanghai, China was recruited to participate in the study. This school is one of the highest performing public schools in a suburban district southwest of Shanghai, China. Most of the students enrolled in the schools are from average, middle-class families.

A total of 36 students signed the consent form and agreed to participate in the study. Fourteen students became absent for either the pretest or the posttest, and were therefore excluded from the final data analysis. The final sample of the study consisted of 22 students, of which 13 were females and nine were males. The teacher instructing the reading program was the general education Chinese language arts teacher of the participating class. The teacher holds a master of arts degree in Chinese language and literature and has five years of teaching experience, all of which were at this school.

Design. The study used one-group pretest-posttest quasi-experimental design. All students received the pretest, reading instruction, and posttest from their language arts teacher. Students' performance on reading comprehension before and after the intervention was compared.

Procedure. Prior to the study, the researcher held a one-hour face-to-face online meeting with the teacher from Mainland China to discuss the purpose of the study and review each lesson of the program. Detailed information, such as how to use reading and writing materials in the class, was also provided to the teacher during this meeting. The teacher was asked to tailor the instruction according to her own teaching style and professional judgment, but was also required to adhere to all of the content and concepts addressed in the program.

The students participated in the study over the course of seven consecutive days, one day for each of the seven sessions of the pilot study. On the first day, all of the students took the pretest. During the second to sixth sessions of the program, students received instruction in their regular reading classes regarding how to read scientific texts using text structure strategies. After each session, students were assigned independent homework, which they were required to complete prior to the next lesson. At the beginning of the next session, the teacher provided the

answers to and the explanations of the homework assignments. The posttest was administered during the last session of the program.

Intervention. The Comprehending Science Texts with Structure (CSTS) Program that was developed by the principle researcher is a five-lesson reading curriculum. The design of the CSTS is based on the work of Williams and her colleagues (2016) and Meyer (Meyer & Poon, 2001), and focuses on the usage of reading comprehension strategies namely generic questions (GQs), graphic organizers (GOs) and summary writing (SW) in reading science texts with structure.

The CSTS program specifically teaches middle school students to read science texts with five types of structure, namely description, sequence, causation, comparison and problem-solution. During the first three sessions, students were taught three reading strategies (GQs, GOs and SW) separately. Specifically, in session one, students were taught how to use GQs to identify the structure of a text. In session two, students learned how to use GOs to organize important information using text structure knowledge. In the third session, students were taught how to write a summary with structure. During the last two sessions of the program, students were required to apply all three strategies to the reading of long paragraphs.

The learning materials provided to students included: 1) 10 short paragraphs and four long paragraphs, 2) definitions and explanations of each types of structure, 3) sample generic questions, and 4) GO and SW templates.

Measures. Measures that developed by the researcher included reading comprehension used to assess comprehension of both science and generic texts. A standardized reading comprehension test was used to assess reading comprehension in general.

Science text summarization (STS). To answer the first research question, which addresses their understanding of science texts, students were required to recall important information from two science paragraphs, one in the pretest and the other in the posttest. For the pretest, a paragraph about dinosaurs with 1079 words was tested. For the posttest, a paragraph about the deep ocean water with 861 words was tested.

Generic text summarization (GTS). To answer the second area of the research question of this pilot study, which addresses students' performance in reading comprehension of expository texts within different domains, students were assigned a task requiring them to summarize generic texts. This test method has been utilized in previous studies measuring the comprehension of expository texts and requires students to recall important information (Meyer & Poon, 2001; Meyer & Ray, 2014; Williams et al., 2016; Williams et al., 2009). Meyer and her colleagues considered the important ideas of a text as top-level structure and measured recall of main ideas using such top-level structure in their studies (Meyer & Poon, 2001; Wijekumar, Meyer, & Lei, 2017). Adopting the same approach, this pilot study also required students to complete a summary of each paragraph they read in the Chinese Reading Comprehension Test in order to measure their performance in comprehension of generic texts. For this test, the first paragraph provided on form A is about the color red with a total word count of 1101. The second paragraph in form A is about Chinese porcelain with a total word count of 838. For form B, the two paragraphs were about ocean water and the landscape of an urban city with total word counts of 861 and 874, respectively.

Chinese Reading Comprehension Test (CRCT). To answer the third area of the research question, which concerned students' performance in reading comprehension in general, the Chinese Comprehension Test on expository text (CRCT) from the High School Entrance Exam

of Shanghai (B. Zhang & Zhu, 2011) was adopted and used in the pilot study. The CRCT is a subtest of the state reading comprehension test, namely the High School Entrance Exam of Chinese Language and Arts (HSEE-CLA). The HSEE-CLA is the province- or city-based performance test for all middle school students take prior to their entrance into senior high school. The HSEE-CLA test usually contains three subscales. The first subscale contains multiple-choice questions about Chinese language and literature. The second one involves reading two pieces of texts, one narrative text and the other expository or argumentative text. Each text is followed by five to seven questions including multiple-choice, fill-in-the-blank, and short-answer questions. The third part of the test is the writing assessment.

The CRCT test used in this study was a subtest of the HSEE-CLA test that focuses on comprehension of expository texts. Four paragraphs are selected and randomly assigned into two parallel forms, A and B. The Form A of the CRCT was administered as a pretest and the Form B of the test was administered as a posttest.

In addition to the total CRCT score, which was used to assess students' overall reading comprehension, two sub categories of the test were also generated to assess two domains of reading comprehension. The first category is the micro-comprehension, which measures students' understanding of words and sentences, primarily using fill-in-the blank and multiple-choice questions. The second category is macro-comprehension, which measures students' understanding of the main idea in each paragraph using short answer questions.

Scoring. The scoring for the state reading comprehension test of the CRCT is based upon the amount and accuracy of the information from the paragraphs, in accordance with the instructions stipulated in the test manual. For the scoring of fill-in-the-blank and multiple-choice items, each correct response receives 1 point, while incorrect responses receives 0 points. For the

scoring of short-answer questions, a fully correct response receives 1 point, a partially correct responses receives 0.5 points, and an incorrect or no response receives 0 points.

The Form A test has a total possible point value of 25, 14 for micro-comprehension and 11 for macro-comprehension. For the Form B test, the total point value is 19, 12 for micro-comprehension and seven for macro-comprehension. The criteria for judging the correctness of each response were determined by two raters with a reliability of agreement of 0.9.

The scoring of the generic text summarization focuses on the recall of idea units from the top-level structure of each text. The total number of important idea units is 22 in the pretest and 28 in the posttest. The scoring of the summary of science texts focuses on the recall of the important science concepts of each text. Both science texts used in the pretest and posttest feature a total number of important science concepts of 19. The scoring protocol used to addressed the important ideas was reviewed and confirmed by two middle school language arts teachers. Two raters scored the protocol independently and reached a reliability of agreement of 0.9.

The final scores on this test were then all converted to the percentages by dividing the number of correct responses by the total score for each test. This conversion was necessary due to the following reasons: 1) The study was based on the one-group-pretest-posttest design, 2) the tests for the pretest and posttest used the two parallel forms, and 3) the total scores for each measure between pretest and posttest were slightly different.

Data analysis. Paired-sample T-tests were conducted to analyze the results, using SPSS 24. Five pairs were created to compare the differences before and after intervention: total score on the CRCT, micro-comprehension of the CRCT, macro-comprehension of the CRCT, generic text summarization, and science text summarization.

Results. Means and standard deviations of each measure, for both the raw scores and percent scores, are presented in Table 1. The standard deviations of all measures appear larger in the posttest than in the pretest. The low variance of the pretest could be due to the high percentage of zero or near-zero scores as many students provided blank answers for some measures.

Table 1

Means and Standard Deviations on Measures of Reading Performance

Measures	N	Percentage Score				Raw Score			
		Pretest		Posttest		Pretest		Posttest	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Chinese reading comprehension test (CRCT)	22	49.91	14.18	68.90	33.24	12.48	3.54	13.09	6.32
Micro-comprehension	22	75.32	18.67	65.91	36.72	10.55	2.61	7.91	4.41
Macro-comprehension	22	17.56	17.37	74.03	31.06	1.93	1.91	5.18	2.17
Generic text summarization	22	.41	1.94	24.35	22.63	0.09	0.43	6.82	6.34
Science text summarization	22	21.05	22.21	26.08	22.88	4.00	4.22	4.95	4.35

The correlations between reading performance measures of the posttest, CRCT, generic text summarization, and science text summarization were calculated; they are presented in Table 2. The results indicated that all measures are significantly correlated to each other. The generic text summarization is significantly correlated to science text recall, with $r = 0.96$, $p < 0.01$, as they are two similar measures evaluating different content domains. Generic text summarization is also significantly correlated to state reading test CRCT with $r = 0.61$, $p < 0.01$. Science text

summarization is also significantly related to the state reading test CRCT with r = 0.62, $p < 0.01$.

The results indicate that three measures of the study are significantly correlated to each other.

Table 2

Pearson Correlations between Reading Performance Measures at Posttest

	1	2	3
1. Generic text summarization			
2. Science text summarization	.96**		
3. Chinese reading comprehension test (CRCT)	.61**	.62**	

** Correlation is significant at the 0.01 level (2-tailed).

The comparison of the students' performance on reading comprehension is presented in Table 3. The effect size of the measures between the pretest and the posttest were also reported, using Cohen's *d* with the pooled standard deviation from the pretest and the posttest. The results indicate that students significantly improved their performance on CRCT, the macro-comprehension subtest of the CRCT. Moreover, the results showed that students also achieved higher scores on generic text comprehension and the recall of important information of the science text. The remaining findings of the pilot study are provided below as each area of the research question is answered.

Table 3

Comparing Means of Reading Comprehension Performance between Pretest and Posttest

Measures	T-Test	Sig. (2-tailed)	Effect Size[*] (Cohen's d)
Chinese reading comprehension test (CRCT)	2.35	.02	.75
Micro-comprehension	1.20	.24	.31
Macro-comprehension	6.25	.00	2.24
Generic text summarization	4.85	.00	1.47
Science text summarization	.89	.37	.22

[*]Effect size was calculated using Cohen's *d* using formula: Cohen's $d = |M_2 - M_1| / \sqrt{(S_1^2 + S_2^2)/2}$

Question 1: Does explicit instruction of text structure within science content help middle school students improve their comprehension of science texts? To address this question, a paired-sample t-test was used to test the summarization of the important information found in science texts. However, the results did not show a significant improvement. Specifically, students increased the summarization of science texts from 21.05 to 26.08, with t(21) = 0.89, *p* = 0.37 and a small effect size (d = 0.22). Although the results suggested that the improvement of science text summarization was not significant, the small effect size indicated a slight association between the intervention and the science text summarization. More comprehensive measures should be developed to investigate the effectiveness of the intervention and its impacts on the increase of science concept knowledge in future studies.

Question 2: Does explicit instruction of text structure within science content help middle school students improve their comprehension of generic texts? To address this question, paired-sample t-tests were used to test the summarization of expository texts. The results indicate that students significantly improved their summarization performance on expository texts after the intervention. Specifically, the findings show that students increased the summarization of texts from 0.4 to 24.35, with t(21) = 4.85, $p < 0.001$ and a large effect size (d = 1.47). The results suggest that the intervention is positively associated with an improvement in students' ability to summarize expository texts.

Question 3: Does explicit instruction of text structure help middle school students improve their reading comprehension in general? To address this question, paired-sample t-tests were used to compare students' performance on the CRCT before and after the intervention. The results indicated that students significantly improved their performance on the CRCT after the intervention. Specifically, students improved their CRCT score from 49.91 to 68.90, with t(21) = 2.35, $p < 0.05$ and a medium effect size (d = 0.75).

In addition, for the two subcategories of comprehension measures included in this test, namely micro-comprehension and macro-comprehension, the results indicate that students improved their performance significantly on macro-comprehension, but not on micro-comprehension. The results indicate that students increased their macro-comprehension from 17.56 to 74.03, with t(21) = 6.25, $p < 0.01$ and demonstrated a large effect size (d = 2.24). However, the results also indicate that the improvement on micro-comprehension is not statistically significant, with t(21) = 1.21, $p = 0.20$ and a small effect size (d = 0.31). The findings on micro-comprehension are expected to have fewer gains because micro-elements were not addressed in the intervention. The results suggest that the text structure intervention was

positively associated with students' gain on the state reading comprehension test, and that this gain may account for their improvement on the on macro-comprehension subtest.

Limitations. This was a pilot study using a one-group pretest-posttest quasi-experimental design. Several limitations affect the interpretation of the findings. The first limitation is the lack of a control group and the related lack of randomization. Another limitation is the small sample. Therefore, in the main study, a larger number of participants were recruited and a true experimental design with randomly assigned treatment and control groups was used to investigate the effects of the intervention. Additionally, the pilot study lacked measures of treatment fidelity. In the main study, the treatment fidelity measures were used.

In addition to the limitations of the design of the study, there were also limitations concerning the design of the text structure instruction; these should be addressed in order to obtain a more complete picture of the potential effects of the intervention. An important consideration is the length of the intervention. The pilot study involved a weeklong intervention intended to teach students how to identify different types of text structure and how to use graphic organizers and summary writing to process important information within the texts. However, through discussion with the teacher and an analysis of the students' work, the researcher concluded that five-sessions of exposure was not sufficient long for the eighth-grade participants to fully understand the types of text structure being taught. Therefore, in the main study, the total learning time was increased to allow for additional discussion and practice with different types of text structure.

Another important issue, that was addressed in this pilot study, concerns summary writing (SW). Summary writing has been considered as one of most important reading and writing strategies (Armbruster, Anderson and Ostertag, 1987). However, in this pilot study, it

was found that many SW worksheets were not completed. When analyzing students' summary writing work, which was assigned as independent homework, it was found that most students had not completed their homework. As a result, the proportion of correct responses on recall was generally low, even for the posttest. To address this problem, it appeared that more scaffolding of summary writing, including explicit instruction, should be incorporated into the text structure instruction.

Finally, it was considered important to develop a better measure of the comprehension of science texts, which was also addressed in the main study. The results of the pilot study do not show a significant difference in the science text comprehension between the pretest and posttest. A possible explanation is that the measure used was not sufficiently sensitive to any science knowledge gains that may have occurred. However, this finding requires further investigation by means of developing a more sensitive measure for the main study.

Conclusion. The pilot study, which investigated the effectiveness of text structure reading instruction—Comprehending Science Text with Structure (CSTS) -- found that text structure instruction can improve students' performance in reading comprehension. The CSTS program has been found to be positively associated with students' improvement in their performance in generic text summarization and on the Chinese Reading Comprehension Test. The purpose of the study was to determine whether the intervention taken as a whole can lead to gain, and the results of the pilot study indicated that the CSTS program was effective. It cannot be determined, however, which element of the intervention accounts for the gains. The main study was therefore conducted to test the effectiveness of the text structure instruction using a true experimental design.

The Present Study

The results of the pilot study demonstrated the feasibility and potential effectiveness of explicit text structure instruction in helping Mandarin-speaking middle school students improve their comprehension of science texts. More importantly, by adapting and implementing Williams' (2016) instruction in a middle school located in another country, the findings from the pilot study upheld the values to the current literature by extending the knowledge of reading instruction into the domain of science and demonstrated the learning effects from reading instruction in science content. Therefore, by extending the findings of the pilot study, the current study aims 1) to contribute to an understanding of content-area comprehension in science, and particularly for Mandarin speakers; 2) to test the effectiveness of a content-area reading intervention consisting text structure; and 3) to contribute to knowledge of students' understanding of text structure as part of the reading comprehension process. In pursuing those clearly defined goals, this study could extend our understanding of how reading comprehension can be improved using text structure strategies in the specific domain of science, and assist to the development of strategies for enhancing science reading in Mandarin settings.

This study focuses on teaching Mandarin-speaking middle school students in Mainland China how to use text structure strategies when reading scientific texts. The instruction focuses on two areas: 1) how to identify five basic types of structure, namely sequence, description, causation, compare-contrast, and problem-solution, and 2) how to use the knowledge of the text structure to acquire important information within a text. This instruction teaches students crucial reading strategies, including Generic Questions (GQs), Graphic Organizers (GOs), and Summary Writing (SW). Thereafter, the study examines whether using these strategies can help students improve their reading comprehension of science texts.

Research Questions

The first research question guiding this study is whether Mandarin-speaking students who receive a text structure intervention gain the knowledge of text structure. This question investigates students' understanding of the nature of text structure. This includes, but not limited to, being familiar with different types of text structure, being able to name the primary type of text structure of a written passage, and being able to present the relationship of important ideas of a text in a graphic organizer. Specifically, two areas are investigated:

1. Knowledge of the structure of science texts;

2. Knowledge of the structure of generic texts.

The second research question guiding this study is whether Mandarin-speaking students who receive a text structure intervention using science texts demonstrate better performance in reading comprehension, comparing to those receiving the reading instruction following a content-only curriculum. Specifically, the study investigates the effectiveness of the text structure reading instruction in the three areas listed below:

1. Comprehension of science texts;

2. Comprehension of generic texts;

3. Scores on standardized reading tests.

In this research, the generic text refers to expository texts in general and the knowledge of structure in generic texts was used as a near-transfer measure. Meanwhile, the standardized reading tests were used as a far-transfer measure. Comprehension of texts relates to students' understanding of texts, reflected in how many important ideas students can identify in a passage.

Hypotheses

The following hypotheses were tested in this study:

Hypothesis 1: Mandarin-speaking students who participate in a text structure intervention using science texts demonstrate better <u>knowledge of the structure of science texts</u> comparing to average middle school students in China.

Hypothesis 2: Mandarin-speaking students who participate in a text structure intervention using science texts demonstrate better <u>knowledge of the structure of generic texts</u> than average middle-school students in China.

Hypothesis 3: Mandarin-speaking students who participate in a text structure intervention using science texts demonstrate better <u>comprehension of science texts</u> than students receiving the content-only reading program?

Hypothesis 4: Mandarin-speaking students who participate in a text structure intervention using science texts demonstrate better <u>comprehension of generic texts</u> than students receiving the content-only reading program?

Hypothesis 5: Mandarin-speaking students who participate in a text structure intervention using science texts demonstrate better <u>scores on standardized reading tests</u> than students receiving the content-only reading program?

The next chapter reviews literature related to text structure instruction and reading instruction in science.

CHAPTER II

LITERATURE REVIEW

Introduction

To investigate the importance of the effectiveness of text structure instruction for comprehending science texts for middle school students of native Mandarin speakers, the current paper reviews studies that investigated the effectiveness of text structure instruction, reading instruction in science content, and reading instruction provided to native Mandarin speakers. In order to gather as much relevant information as possible, all grade levels are included, through postsecondary. The review of literature covers four domains: 1) theoretical framework for understanding text structure, 2) text-structure-based instruction for enhancing reading comprehension, 3) reading instruction for science texts, and 4) reading instruction for Mandarin speakers. Within those four domains, this literature review focuses on answering the following questions:

1. What is text structure, and why it is important in comprehending expository texts?

2. What outcomes have been reported on text structure interventions for improving reading comprehension?

3. What outcomes have been reported on reading comprehension interventions using science texts at the elementary, secondary, and postsecondary levels?

4. What reading comprehension interventions have been reported involving native Mandarin-speaking participants?

The first section of this review presents a theoretical framework for understanding text structure, including the common types of text structure identified in the literature, and the importance of awareness of text structure in the processing of text information. The second

section reviews studies on the effectiveness of teaching text structure strategies in academic

settings. Although the main interest of the current author is the middle school level, due to the

limited number of studies reported at that level, this section reviews studies at all school levels

from early elementary to postsecondary. The third section of this chapter reviews reading

instruction that specifically focuses on science texts throughout the educational levels. This

section also discusses the effectiveness of integrating reading strategies into science learning at

all those levels. The fourth section of this literature review discusses research on reading

instruction for native speakers of Mandarin. In this literature review, the discussion will focus on

details of methods, findings, and limitations that are extracted from key studies while less well-

known studies will be briefly mentioned as supporting information.

       Method. To reflect the more recent developments in this area, this literature review

explores scientific and technical papers published between the years of 2000 and 2019. This

work is complemented by a few sources with earlier publication dates that were discovered in

bibliographies of identified studies. Relevant studies were identified using the ProQuest

database, bibliographies of identified papers, Google Scholar, and a print search of relevant

journals. Studies conducted in Mandarin were identified using the China National Knowledge

Infrastructure (CNKI) database. Literature included in this review consists of peer-reviewed

journal articles, technical reports from known agencies, doctoral dissertations, and scholarly

books. Literature identified in the search was selected for discussion in this review if it contained

empirical evidence relevant to the current questions, as listed above. In addition, although the

primary interest of this study is teaching text structure strategy in comprehending science texts,

studies using any content area were screened in when the studies on text structure were reviewed

due to the scarcity of literature using science text. Therefore, only the studies meeting the

following criteria are included in the literature review: 1) it must be an empirical study; 2) it should be conducted in school settings; 3) the topic of the study should be related to text structure or reading comprehension instruction in science.

Search terms used to identify the studies for this review include "text structure," "comprehension," and "reading instruction" within the abstract. One hundred thirteen peer-reviewed studies were returned from this search. For reading instruction in science, the keywords were "reading instruction," "comprehension," and "science" within the article abstract, and 140 studies were returned from this search. In addition, for the reading intervention study in Mandarin, the keywords were yue du ce lve [reading strategy], zhong xiao xue yu wen [teaching Mandarin for K-12], shi yan [empirical study], and only 21 studies were identified in this search. Identified studies were organized according to the grade level, elementary, middle school, high school, and college level, respectively, and each individual study was read to determine if it met the criteria for this review. Finally, 12 studies about text structure, 13 studies on reading science, and six relevant studies reported in Mandarin were selected for review.

Theoretical Framework for Understanding the Role of Text Structure Knowledge in Reading Comprehension

Use of knowledge of text structure to comprehend expository texts has been considered an important way for readers to build coherent mental representations for encoding and retrieving information from the text, as text structure is hypothesized to help readers to understand how the important ideas of a text are inter-related (Goldman & Rakestraw, 2000; Meyer & Poon, 2001). According to Meyer and her colleagues (Meyer & Poon, 2001), texts are usually constructed hierarchically, which allows ideas to be presented in a hierarchical order based on importance, where the most important ideas are placed on the top of the hierarchy while

less important information is placed on lower levels (Schwartz, Mendoza, & Meyer, 2013; Wijekumar, Meyer, & Lei, 2013). Meyer argued that while there may be multiple structural patterns within a text, there is generally a "top-level" structure creating a hierarchy based on rhetorical relationships among the ideas represented by the various text structures. According to this view, such top-level structure of expository text can be classified into five basic types: description, sequence, comparison-contrast, causation, and problem-solution (Cook & Mayer, 1988; Meyer, Brandt, & Bluth, 1980; Meyer & Freedle, 1984).

According to Meyer and Freedle (1984), "description" is a type of structure in which elements in a text are grouped and organized by association, and one element of the association is subordinate to another (the topic). In addition, the description structure conveys information about a topic by presenting attributes, specifics, or settings. "Sequence" is a structure in which ideas are grouped on the basis of order or time. The "comparison" structure organizes information on the basis of similarities and differences, while the "causation" structure presents elements that are grouped before and after in time and are causally or quasi-causally related. Last, the "problem-solution" structure provides a way to organize main ideas in two parts: a problem and a solution that responds to the problem by trying to eliminate it, or a question and an answer that responds to the question by trying to answer it.

In addition to the five basic types of text structure Meyer and her colleagues classified, studies in the early 1980s mentioned some other types of structure. For example, Cook and Mayer (1980) indicated that the five common types of expository text structure found in science textbooks were Generalization, Enumeration, Sequence, Classification and Comparison/contrast. Their categories are partly different from those identified in Meyer and Freedle (1984). Specifically, Cook and Mayer indicated that "Generalization" passages always have a main idea,

and most of the other sentences in the passage try to provide evidence for the main idea by either clarifying or extending, while "Enumeration" texts showed list of facts one after another. Another study conducted by Holley and his colleagues (1977) sorted the texts into three types: Hierarchies (type/part), Chain (lines of reasoning/temporal orderings/causal sequence), and clusters (characteristics/definitions/ analogies). More recently, Meyer and Ray (2011) identified common text structures as Comparison, Problem-and-solution, Cause-and-effect, Sequence, Collection, and Description. In that categorization, "collection" is added into the set and is defined as either listing or enumeration, and sequence is treated as a subtype of collection. Those studies demonstrated that common types of text structure of expository texts include causation, comparison, sequence, collection and description, although there are different expressions about the collection, description and sequence.

Knowledge of text structure plays a crucial role in processing and memorizing information, and making judgments during reading. One notable benefit of text structure is that it facilitates the identification of important ideas and their memorability (Goldman & Rakestraw, 2000). It is argued that when readers are processing information from a text, due to limited cognitive capacity, they cannot remember and learn everything presented. Therefore, it has been suggested that focusing on the high level or the top-level of the structure of text could help readers select the most important information thorough encoding. For example, Meyer and her colleagues found that students who used the top-level structure strategy were able to remember more of what they read and more important information from the paragraphs than those who did not use the strategy (Meyer et al., 1980; Meyer & Poon, 2001).

Moreover, some studies suggested that comprehension of unfamiliar domain knowledge may benefit from the utilization of text structure. These studies have indicated that when readers

are less familiar with and have little knowledge about a specific domain, their comprehension depends on the text structure (Goldman, 1997). For example, McNamara, Kintsch, and Songer (1996) examined comprehension performance between readers with low domain knowledge and high domain knowledge. Their study randomly assigned students from grade 7 to grade 9 into four groups, who were assigned to read a text about heart disease. Base text was modified in four versions: 1) a text well-structured at both the local level and the top level, 2) a text well-structured at the top level but not at the local level, 3) a text well-structured at the local level but not the top level and 4) a text ill-structured at both the top and the local level, where top level represents the most important information while local level presents the less important information. The study tested students' prior knowledge about the content and their reading performance using text recall, written questions, and key-word sorting measures. The results suggested that readers with less familiarity with the content demonstrated superior reading performance of literal and inferential comprehension and problem-solving when they were provided more cohesive texts with sentences connectives (e.g., phrases that explicitly linked ideas together using topic headings and topic sentences).

The learning of text structure appears to play a crucial role in children's literacy development in reading informational texts (Williams, Hall, & Lauer, 2005). According to the Common Core State Standard for English Language Arts and literacy (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), students at second grade should start to learn and be able to use text features to locate facts and identify main idea of a text. At grade four, students should learn to describe all types of text structure including sequence, comparison, cause-effect, and problem-solution. From grade 6, the Common Core states that students should use the knowledge of text structure to analyze the text about how

the authors organize the information. By grade 12, the Common Core states that students should be able to analyze and evaluate the effectiveness of structure that an author uses in a text. Moreover, the Common Core Standard for literacy in Science and Technical Subjects, also indicates that students should learn how the texts are organized by grade 8, analyze the structure of the relationships among concepts in a text by grade 10, and analyze how the text structures information into categories, as a way to demonstrate the understanding of information.

In order to meet these standards, a variety of intervention techniques have been investigated to evaluate their effectiveness in making readers more knowledgeable about text structure. Those investigated techniques include teaching readers to follow the text structure used by the author, employing adjunct aids to highlight the structure, and creating visual representations of the text structure. More importantly, those studies that investigated the effects of teaching a variety types of text structures including causation, description, comparison, sequence, and problem-solution have all demonstrated promising results (Goldman & Rakestraw, 2000). Therefore, it is important to extend the findings from those studies to a specific subject domain, especially science, and to the different groups such as middle school students and native Mandarin speakers.

Outcomes of Text Structure Interventions on Reading Comprehension

Extensive literature has demonstrated that students with more knowledge of text structure show better performance on reading comprehension in the primary grades through high school and beyond (Bohn-Gettler & Kendeou, 2014; Meyer et al., 1980). Moreover, there is a large body of research indicating that readers at any age can benefit from the explicit instruction of text structure (Gersten, Fuchs, & Williams, 2001; Meyer & Ray, 2011; National Reading Technical Assistance Center, 2010). Research on text structure interventions began in the late

1970s with work by Meyer and here colleague (Meyer & Ray, 2011). Initially, most of these studies focused on teaching text structure to college students and adult readers; later studies focused instruction on secondary and elementary students. More recently, there has been growing interest in studying text structure instruction for a diverse population, including at-risk students and students with reading disabilities as well as second language learners (Kao, 2015). This section reviews research on the direct instruction of text structure under the following categories: 1) Teaching Expository Text Structures to Early Primary School Readers, 2) Teaching Expository Text Structures to Upper Primary and Middle School Readers, 3) Teaching Expository Text Structures to High School Readers, 4) Teaching Expository Text Structures to College Students, and 5) the Results from Mata-analysis of Text Structure.

The effects of text structure instruction for early primary students. Previous studies have indicated that early primary school students can benefit greatly from learning text structure. Addressing the importance of improving students reading comprehension from the second grade, William and her colleagues (Williams et al., 2006; Williams et al., 2009) developed direct instruction through academic content to at-risk children. Students were learning text structure as well as science or social studies content through teacher modeling, scaffolding that faded when the instruction progressed, and substantial practice at each step (Williams & Pao, 2011). In these studies, students were trained with structure strategies including using signal words and generic questions, constructing graphic organizers, and writing summaries for different types of structure. For example, Williams and her colleagues (Williams et al., 2016) developed a text structure instruction called Close Analysis of Text with Structure. The instruction covered five basic types of text structure including sequence, comparison, causation, description, and problem-solution and was embedded in a social studies curriculum that focused on U.S.

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historical communities, including the Sioux, colonists, pioneers, immigrants, and modern urban

residents (New Yorkers). During the study, students were taught how to identify the text

structure using generic questions, how to use a graphic organizer to organize the important

information, and how to write a summary using the knowledge of text structure to each type of

the structure. A total of 50 lessons spanned a year, where each module that covered one type of

structure was taught in 10 sessions. The patterns for each module of the instruction were similar:

it started with the introduction of the text structure and social studies content, followed by each

strategy, including generic questions, graphic organizer and summary writing, taught

respectively, and concluded with the last two sessions as review sessions.

A total of 258 students from 16 classrooms were recruited from elementary schools in

New York City. Classrooms were randomly assigned into treatment group, content group, and

control group. Students' reading ability levels were assessed using the Gates-MacGinitie

Reading Test (GMRT) before the intervention, which indicated that students from different

schools and classrooms were at the same level. Reading performance, including knowledge of

text structure, passage comprehension, and social studies content was assessed using the

researcher-developed test (Williams et al., 2016).

Measures that were used to assess students' performance included the GMRT, researcher-

developed end-of-unit tests and a researcher-developed pretest and posttest. For the end-of-unit

test, students completed the measures of comprehension/written-summary,

comprehension/transfer and vocabulary. For the pretest and posttest, students were assessed

using the following measures: 1) strategies for text analysis, 2) comprehension/written summary,

3) comprehension/transfer, and 4) content. In order to measure strategies for text analyses,

students were required to complete a multiple-choice test about clue word identification, strategy

question identification, and graphic organizer identification, which asked students to choose the correct answers related to the text structure. For example, students were asked to identify the text structure of a given graphic organizer. The measure of comprehension/written-summary asked students to write a summary about the paragraphs. Students were scored on whether they included the main idea sentence and structure statements with clue words. The comprehension/transfer measure included the sentence completion which asked students to fill in the blanks using the correct "clue words" related to text structure and the reading comprehension test, which asked students open-ended questions about the main ideas of the paragraphs that were new to them. The content measure included a cloze test about vocabulary and open-ended questions about the features of the historical communities in the program. All measures that were developed by researchers in this study were scored using the proportions correct, which means that all the measures had a score ranging from 0 to 1(Williams et al., 2016).

After an analysis of the results using hierarchical linear model, the study indicated that the performance of the intervention group was significantly better than that of the other two groups on the reading comprehension and text structure measures. Specifically, the study indicated that treatment (TS) group performance was significantly better than the content group (CT) and the no-instruction group (NI) on their posttest of written summary of main idea (TS, M = 0.80, d = 0.28; CT, M = 0.29, d = 0.34; NI, M = 0.22, d = 0.28, $p < 0.001$) and structure statements (TS, M = 0.60, d = 0.35; CT, M = 0.18, d = 0.22; NI, M = 0.14, d = 0.21, $p < 0.001$). The results also showed that the TS group performed better than the other two groups on the two measures of transfer, including the sentence completion (TS, M = 0.50, d = 0.35; CT, M = 0.24, d = 0.27; NI, M=0.20, d = 0.25, $p < 0.05$) and comprehension questions (TS, M = 0.80, d = 0.28; CT, M = 0.29, d = 0.34; NI, M = 0.22, d = 0.28, $p < 0.01$). In addition, the study also suggested

that the TS group outperformed on the three strategies (clue words identification, strategy questions and graphic organizer) of test structure when compared to the other two groups. Moreover, for social studies content measures, the study found that the intervention group and content group both performed better than the control group, indicating that embedding the text structure training in a content area did not lessen the content acquisition (Williams et al., 2016).

Williams' studies indicated that strategies including identifying the text structure, using a graphic organizer, questioning, and summation were all effective for teaching text structure ((Williams et al., 2005; Williams et al., 2016; Williams et al., 2006; Williams et al., 2009). More importantly, those studies demonstrated specific benefits from learning expository text structure, including improvement in knowledge of content as well as knowledge of text structure. Based on those important findings from the Williams' studies of text structure instruction on primary elementary students, it would be crucial to extend those findings to the students in different levels and to investigate if these effective strategies including questioning, graphic organizer, and summary writing would benefit various students, such as English as a Second Language students, students with special needs, or students at the middle school level or above. In addition, it would also be important to extend the findings from Williams's studies on social studies to other subjects, especially the science texts that are challenging to many students.

The Effects of Text Structure Instruction for Upper Primary and Middle School Students

The effects of teaching text structure demonstrated among young readers.
Armbruster, Anderson, and Ostertag (1987) taught fifth grade students how to identify the text structure and how to use the problem-solution text structure to write a summary in social studies content. Focusing on the students who were from the remedial reading classes or who scored below fourth-grade level on the Gates-McGinite Test, the instruction took place over 11

consecutive days among 82 fifth grade students, for 45 minutes per day. It featured teacher modeling, guided practice, teacher monitoring with corrective feedback, and independent practice to train students on recognizing and summarizing problem-solution passages in social studies. The researchers provided students with a workbook, which included the definition and description of problem-solution text structure, the rules of how to write a summary of problem-solution passages, 13 problem-solution passages from social studies textbooks, and sample problem-solution graphic organizers for students to use.

In addition to providing materials to the students, the researchers (Armbruster et al., 1987) taught the problem-solution framework in the classroom. During the first two sessions of the training, students were introduced to the problem-solution text and how to writing a problem-solution summary. During the third through ninth sessions, students were asked to practice summary writing on their workbook while the researchers walking around to provide help. During the last two sessions, students were required to discuss the reading materials from their regular social studies content using the knowledge of problem solution.

After the training, students were given an immediate test on reading comprehension and a week-delay test (Armbruster et al., 1987). The researcher-developed test consisted of an essay test of recall of main idea, a short-answer test of recall of facts, a written summaries test, and a delayed essay test. For the recall of main idea, the students were required to read a passage from their textbook and then to write an essay about the structure, with specific questions provided by the researchers, such as "What were the problems that settlers faced on the Great Plains? How did they solve those problems?" Students were scored based on relevant propositions that they recalled from the passages. For the short-answer test, students were required to answer 10 short-answer questions about the information of the text such as "what is homesteading?" The total

correct response was calculated. For the writing summary test, the assessment was to write the summaries of two passages from their social study textbook. To score the writing summaries, the study assessed them through importance levels and quality. The researchers developed a 5-point scale protocol to assess the importance levels of each passage. In addition, the researchers also developed a 6-point scale to evaluate the quality of writing (Armbruster et al., 1987).

Eight-two participants were enrolled from four classrooms of two schools, two from each school, in a small inner Mid-western city in the United States. For each school, one classroom was in the treatment group and the other classroom was in the comparison group. The comparison group received the same reading materials. However, after reading the passage of each lesson, students in the control group discussed the questions accompanying each passage rather than receiving the text structure training (Armbruster et al., 1987).

The results of the study (Armbruster et al., 1987) indicated that the trained students could recall more information (M=37.4) than the comparison group (M=25.6), with $p < 0.01$. Moreover, the study suggested that the students who received the text structure training could recall more important ideas in written summaries of a text than the students who were receiving the traditional reading class, with $p < 0.001$. Those findings indicated the promising effect of teaching the problem/solution pattern at the upper elementary level. However, it is important to investigate the effectiveness of other text structures such as cause-effect and comparison on this level. Moreover, it is also important to extend the current study into a larger scale.

Another study (Moore, 1995) also developed an intervention based on collaboration and integration of reading and writing to enhance expository reading comprehension, this time with sixth graders. Focusing on two rhetorical structures, compare/contrast and cause/effect, the study incorporated scaffold instruction following the master/apprenticeship model, procedural

facilitation using graphic organizers, and novice/peer group work. Students in the study were taught about writing passages from graphic organizers and reading passages to create graphic organizers.

The treatment students received the training during their reading classes, which met every other day for 12 weeks, while the control group students attended regular reading classes with the same reading content. Students were trained how to write passages with the information from graphic organizers and then to create graphic organizers when they were reading passages. Reading materials were selected from students' textbook and magazines. Passages were tailored to fit sixth to seventh grade readability. Moreover, all training sessions were conducted by teachers' modeling first, followed with group work, and individual practice last.

The study (Moore, 1995) recruited 76 regular students from two schools who were participating in the reading program provided for all sixth grade students by the local public school system. Students were tested on five occasions on the levels of structure awareness, percentage of idea units recall, and comprehension. The comprehension test was modeled after the National Assessment of Educational Progress multiple-choice test, which asked students to finish five questions after the reading of the passage. Overall, all students received five researcher-developed tests including a pretest, two tests in the middle of instruction, one test at the end of the training, and one delayed test at the end of the semester. The results showed that the treatment group outperformed the control group in terms of growth of structure awareness, number of idea units remembered, and the test of reading comprehension. Moreover, the study applied the hierarchical linear model to evaluate the growth of structure awareness, idea units memorization, and comprehension, and the results indicated that all three measures gained significant coefficients of the growth rate with $p < 0.01$. However, there are some limitations of

the study. The first is the reading materials that the students used in the study. The researcher modified the passages into 200-word short passages, thus students had little exposure to authentic texts in the study. The second issue regards expository writing. One of the main purposes of the study was to integrate writing and reading; however, the study did not report any measure in writing or improvement in writing skills. Therefore, those important questions should all be addressed in further studies.

Another important study of text structure training at this level is the web-based delivery of structure strategy intervention developed by Meyer and colleagues (Meyer et al., 2002) for fifth grade readers. The students in this study learned the structure strategy with feedback and support from their personal tutors via the Internet. Those online tutors were all older adults and had received eight sessions of text structure strategy training before tutoring. In addition to training in text structure, tutors also received information about how to identify students' difficulties, how to enhance students' engagement, and how to scaffold.

Students in the study (Meyer et al., 2002) learned five basic types of text structure including comparison, problem-solution, cause-effect, description and sequence. Through the training program, they were taught: 1) to identify and use the top-level structures to organize their ideas, 2) to recognize the structures in everyday reading material, 3) to use the structures as a framework for acquiring new information, and 4) to reorganize and rewrite the important information of the text using the knowledge of text structure.

Twenty-five lessons developed by the researchers (Meyer et al., 2002) were delivered to students via the Internet. Students learned the five types of text structures one by one. The intervention consisted of five lessons of comparison, eight lessons of problem-solution, eight lessons of cause-effect, two lessons of sequence structure, one lesson of description, and a

review lesson. Students took three 20-minute sessions each week to learn the text structure in their computer lab. Their tutors were required to communicate with the students three times a week about their learning.

A total of 60 students were enrolled from a rural middle school in northwestern Pennsylvania to participate in the study (Meyer et al., 2002). Their reading skills, which were reported by the school using the Reading subtest of the Iowa Tests of Basic Skills, were higher than average reading skills, with a mean of 70.25. The study took place on school's Accelerate Reading program, which required students to read storybooks and complete comprehension tests on the computer about the story for 9 weeks. Participants were randomly assigned into three groups: the first was the text structure-training group with tutors, the second was the independent learning of text structure without tutors, and the third was the control group. Since the instruction was conducted via Internet and no school teachers were involved in the study, 80% students worked through lesson 14 and only 10% students reached lesson 25.

The study (Meyer et al., 2002) measured students' standard reading ability using the STAR reading test and students' reading and writing performance using passages from magazines for ninth graders. For the assessment of reading performance, students were asked to read one 563-word passage organized with a comparison structure and one 355-word passage organized with a problem-solution structure, and then asked to recall as much information as possible after the reading for both pretest and posttest. Both passages had 180 scorable idea units. The study scored the idea units as "recalling" and the main idea units as "main idea." The ability to use top-level structures was also judged based on text recall. The researchers developed a rubric with six levels of text structure use for judgment and scored the recalling based on this rubric in addition to the content information about the passages that students read. In addition,

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for the problem-solution passages, students were asked to identify the problem, the causes of the problem, and the solution to the problem, where each part was given six credits. To measure writing performance, students were asked to write a comparison article about frogs with the information provided by the researchers. To score writing performance, two researchers sorted the essays into seven piles and scored them from 1 to 7. A delayed posttest was also conducted 2.5 months after the training. Students were asked to read a comparison text and a problem-solution text and recall information from the passages.

The results of the study (Meyer et al., 2002) indicated that the training group of text structure with tutors (STWT) recalled more information than the control group on the immediate posttest (strategy group, M = 56.30, SD = 36.96, control group, M = 39.60, SD = 23.11, *p* 0.03) with medium effect size (d = 0.74) and on the delayed posttest (STWT group, M = 42.63, SD = 21.73, control group, M = 27.67, SD = 16.23, p < 0.01) with a large effect size (d = 0.92). It also indicated that STWT students performed significantly better than the control group on delayed posttest for recall of main ideas (STWT group, M = 23.37, SD = 11.93, control group, M = 14.73, SD = 9.16, p < 0.05) with a large effect size (d = 0.92) and questions about main ideas (STWT group, M = 8.90, SD = 5.39, control group, M = 3.25, SD = 1.49, p < 0.01) with a large effect size (d = 0.92). For the measure about text structure, the study also found that the STWT students scored significant higher than the control group on using text structure when they were recalling information (STWT group, M = 5.08, SD = 1.74, control group, M = 3.25, SD = 1.49, p < 0.01) with a large effect size (d = 0.92). However, the study did not find any significant difference between those groups in STAR test and writing performance.

Based on those effective findings from the web delivery of structure strategy, Meyer and her colleagues improved their online teaching system called Intelligent Tutoring of the Structure

Strategy (ITSS) to teach text structure to fifth and seventh grade students (Meyer et al., 2010; Wijekumar, Meyer, & Lei, 2012; Wijekumar et al., 2013; Wijekumar, Meyer, Lei, & Lin, 2014). The ITSS system emphasized two of the most complex and difficult text structures – comparison and problem-solution – because of their primacy in the order of instruction, and then integrated other structures including sequence, cause-effect, and description through the series of lessons. Moreover, the computer system provided students with personal feedback and personal choice of texts to read and incorporated three basic steps of the structure strategy in training: identifying signal words and classifying the text structure of a passage; writing a thorough main idea for the passage; and creating a recall of the passage using the signal words and main idea. Therefore, the ITSS could allow students to interact with an animated agent/tutor to learn and practice the structure strategy and receive immediate feedback, and has the potential to offer consistent modeling, practice tasks, assessment, and feedback to the learner, as well as opportunities for individualized instruction. The ITSS system provided 65 lessons on five types of text structure and 30 practice lessons. In addition, the lessons covered 145 texts from authentic sources including science, social studies, animals, sports, and food.

While most related studies focused on the improvement of the ITSS system, Mayer and her colleagues also conducted an intervention among 56 fifth-grade students and 55 seventh-grade students for 6 months (Meyer et al., 2010). During the intervention, students from the regular classes were recruited to participate in a self-paced program for two or three sessions each week. Their performance was measured by a standardized reading comprehension test using the Grey Silent Reading Test and experimenter-designed tests including information recall, top-level structure, and competency rating for text structure. The results demonstrated the effectiveness of the ITSS. They indicated that all students gained significant increases in their

information recall after training. On the measure of competency, the study also suggested that students scored significantly better after training. Moreover, the study found that students who received the ITSS training with elaborated feedback performed better on the Grey Silent Reading Test than students who received simple feedback from the ITSS system.

Meyer's studies provide a fundamental picture of teaching text structure to students at the elementary and middle school level, as these studies involved many basic elements of teaching text structure (Meyer et al., 2002; Meyer & Poon, 2001; Meyer et al., 2010; Wijekumar & Meyer, 2006; Wijekumar et al., 2012, 2013; Wijekumar et al., 2014). Those studies covered all five basic types of rhetorical patterns of expository text and several important reading strategies for text structure including using signal words, summarizing important ideas, and writing using text structure skills. However, most of the studies at the upper elementary and middle school level were focused on the development of online reading systems but lack evidence of the effectiveness of teaching all types of text structure to students. Consequently, the designs of these studies lack some important comparisons, such as comparing the effects between online teaching and classroom teaching and the comparison between the treatment group with the control group who received the same reading materials but not the text structure strategy training. Therefore, it would be important to extend such studies into real classroom settings.

Another study (Hoffmann, 2010) investigated the effects of the graphic organizer and metacognitive monitor strategy on comprehension of science text. The study taught fifth grade students how to construct the graphic organizer of compare-contrast passage using a metacognitive monitor strategy for 5 weeks. The study developed a checklist for students to learn of metacognitive strategies before, during, and after reading. In addition, students were trained on how to build a matrix using the steps when they were reading expository passages. Teachers

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provided modeling and scaffolding at the beginning of program. During the sessions in week five, students were asked to read passages and build the matrix independently.

A total of 162 fifth grade students and seven teachers who were recruited from a large public elementary school in South Carolina were involved in the study for 9 weeks (Hoffman, 2010). Seven classrooms were randomly assigned into four different conditions: graphic organizer + metacognitive monitoring, graphic organizer, metacognitive monitoring or the control group. The instruction took place two times a week for 50 minutes each session for all students. The study measured students' knowledge of metacognitive strategies and reading comprehension. The metacognitive strategies were measured using Jr. Metacognitive awareness inventory and Metacomprehension Strategy Index. For reading comprehension, besides the the GMRT, students were assessed each week using researcher-developed multiple-choice comprehension measures when they were reading new passages in class. Test items included inference questions, fact-level questions, vocabulary questions, and main idea questions.

The results of Hoffman's (2010) study indicated that, compared to the students who only received training on graphic organizer or metacognitive instruction, and those in regular reading classes, students who received the training on graphic organizer plus the metacognitive monitor significantly improved their scores on the GMRT, with $P < 0.02$ (Hoffman, 2010). However, after analyzing students' performance on passage comprehension using a multilevel linear model, the study did not find any other significant difference between those conditions after students' vocabulary and metacognitive awareness were controlled.

In summary, the upper primary and middle school studies indicated that many strategies, including identifying the text structure, summarizing, and graphic mapping were all effective in improving students' knowledge of text structure. More importantly, the studies found that

instruction on text structure can significantly improve students' performance on standardized reading comprehension tests and information recall measures. In addition, the studies also demonstrated the effectiveness of teaching text structure using an online tutoring system, which not only taught the knowledge of text structure but also increased students' motivation to learn by providing personal feedback and options for tasks.

In addition, compared to those that have been conducted at high school and college levels, studies at the primary and middle school level have several distinctive features. The first is the types of text structure taught. Most studies at this level focused on the basic types of the text structure and on one or two patterns, especially on problem/solution and cause-effect patterns. Moreover, the interventions at this level showed more scaffolding. Most studies involved teacher modeling, group work, and independent practice. Also, the review of the studies at this level showed that most of the studies were focused on the upper elementary level, with a relative shortage of middle school studies. This gap needs to be addressed in future research.

Text structure instruction for high school students. Previous studies have also demonstrated promising effects of teaching text structure strategies to students at the high school level. Hickerson (1986) developed direct instruction to teach text structure to seventh and tenth grade students, using a variety of expository passages with science, history, and language content developed by the researcher. By explicitly teaching students four patterns of text structure including listing, sequence, compare-contrast, and cause-effect, the study focused on 1) the determination of typical organizational patterns used in the text, 2) the development of a note-taking strategy for organizing information based on the analysis of text, and 3) the application and transferring of text structure to independent expository text reading and writing. The focus of

the instruction was the explanation, modeling, and guided practice in recognizing and identifying each of four basic patterns of text structure and in organizing information according to the text structure. Therefore, students were given many types of passages -- first the short passages and later long and complex passages -- to identify the structure and to take notes using webs or mappings of the passages. Moreover, students were required to write an expository essay using the patterns they had learned from the lesson. The last thing that students were trained to do was to apply their text structure knowledge to poorly structured text passages.

The study took place over 6 weeks among 60 seventh-graders from developmental reading classes and 60 tenth-graders from regular English classes (Hickerson, 1986). The classes were randomly and equally assigned into the treatment group and comparison group. The comparison group in the study did not receive any instruction in text structure, nor did they receive the instructional materials..

To measure the outcomes, the study conducted pre- and post-tests on four measures developed by the researcher: 1) attitude towards expository text, 2) independent reading comprehension and recall from expository text that asked student to finish multiple-choice test based on the materials they had read, 3) organization of information from expository text in note-taking, which required students to read an expository article according to their grade level and to take notes from the article, and 4) expository writing which asked students to write an expository text using text structure knowledge from the given topics (Hickerson, 1986).

The results indicated that the students who received the training in text structure of expository text performed significantly better than those in the control group in comprehension and recall (Hickerson, 1986). Both seventh grade and tenth grade students showed significant improvement on information recall of expository texts, with $p < 0.01$. In addition, seventh grade

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students in the treatment group showed better performance on note taking than those in the control group, with $p < 0.01$. However, the results of the study suggested that neither the seventh grade nor the tenth grade students showed gains in expository writing.

Based on the findings from this study (Hickerson, 1986), there are several interesting questions that are worth further investigating. The first is to differentiate the instruction between the seventh and tenth grade. Both grades in the study received the same instruction without considering their difference in reading ability. Another question is the transferring of reading skills to writing skills. Although the instruction trained students on expository writing at some point, it seems the training in writing that was given was not effective, and thus the results of the study showed that neither the seventh graders nor the tenth graders improved their writing of expository text. This finding suggested that effective methods of teaching expository writing should be further investigated. In addition, the study is flawed because the un-equivalent design between the treatment and comparison group; comparison group did not receive the same reading materials as the treatment group. Therefore, it is difficult to attribute the effectiveness of learning to the instruction.

In another study, Russell (2005) developed a task-through-text instructional framework that was situated within designed discourse communities for ninth grade. In order to determine the overall literacy growth of struggling adolescent readers and the effectiveness of text structure instruction and to track intrinsic motivational changes related to reading, the study developed direct instruction in text structure for students with a low level of reading ability. The main focus of the study was on four characteristics of expository text including links to interest and prior knowledge, sufficient density of ideas, clear rhetorical patterns, and clear signaling devices. The task-in text framework in the study involved three phases of training: 1) rereading familiar text,

2) direct guided reading with word study mini-lessons that focused on general reading comprehension strategies, and 3) taking apart the text, which specifically focused on text structure strategies. Furthermore, the study trained students to read texts that covered the topics of biology, physics, and social studies from the Steck-Vaughn Pair-it Series using pre-reading strategies, using reading strategies such as questions and graphic mapping and after-reading discussion and journal writing.

The study included 40 students, 22 in treatment and 18 in control, in a 6-month intervention (Russell, 2005). The 22 students from the treatment group were assigned into six small special reading classes based on their reading level to receive training in text structure. Each small group of reading class was considered an individual discourse community, and students met one session with their instructor per day. All groups met the same instructor during the intervention. Moreover, students received similar training during each session including re-reading familiar text, direct guided reading with word study mini-lessons, and taking apart the text/personal response journaling and discussion. Students learned text structure in their first 9 weeks of intervention and worked on journaling instruction in the remaining 9 weeks of the intervention.

To measure the outcomes, the study adopted the Qualitative Reading Inventory-3 (QRI-3) to evaluate students' literacy growth, including oral reading, silent reading, and listening skills (Russell, 2005). The study selected 10 science passages from QRI-3 for the pre- and post-test, and those selected passages varied from pre-primer level to high school level. Moreover, using the measure of story retelling and summary of QRI-3 texts, the study scored students' performance on recalling of idea units on top level and use of rhetorical patterns in addition to measuring how students could use text structure tools in reading comprehension and writing.

The results of the study indicated that the students received the treatment showed a significant growth of their literacy with $F (1,28) = 164.64$, $p < 0.01$ (Russell, 2005) The study also suggested that students in the instruction group who received text structure instruction scored meaningfully better on QRI-3 retelling than their peers in the control group ($F (1,28) = 18.369$, $p < .01$). Those findings demonstrated that students receiving intervention on text structure are superior in overall literacy growth as well as their ability to use and transfer knowledge of text structure. However, the study did not describe how the control instruction was different from the experiment instruction, and this would make it difficult to attribute the effects of learning directly to the text structure instruction.

In summary, the studies reviewed above indicated the effectiveness of strategies including identifying the text structure using signaling words, reorganizing the important information from the text, and graphic mapping. Both studies reviewed above showed that learning text structure can significantly improve high school students' performance on the standard test of reading comprehension and information recall. They also indicated that training in text structure can also contribute to the overall literacy growth for high school students. Moreover, both studies indicated that students could benefit from learning many types of text structure and thus improve their reading ability on expository text. However, the studies reviewed above showed inconsistency in text patterns, where one study focused on list, topical net, linear string, matrix, falling dominoes, branching tree, hierarchy, and argument while another study focused on listing, time order, compare-contrast and cause-effect. It would be important to investigate the text structure in a consistent way. For instance, the investigation could start with the basic patterns including description, sequence, causation, comparison, and problem-solution and then target some patterns or some combinations of patterns that would be

particularity difficult for high school students.

More importantly, studies that focused on high school students demonstrated that high school students could gain benefits from explicit instruction of text structure. Both studies reviewed above showed that it took much more time to explicitly teach reading instruction at the high school level than at the college level. These findings indicated that for high school students, it is necessary to develop a long-term direct instruction in text structure and it is worthwhile to investigate several questions, such as how to teach expository writing of text structure effectively, or how to differentiate the text structure instruction between regular students and students with special needs, in future studies.

In addition, both studies reviewed above showed similar issue in their study design – the instruction that the control group received was unknown or unclear, which means it is hard to attribute the effects of learning directly to the instruction. Therefore, further studies should also be aware of the equivalent design between treatment group and comparison group.

Text structure instruction for college students. Several studies have shown positive results in teaching expository text structures to college students. For example, Cook and Mayer (1988) investigated the effectiveness of teaching text structure for college students in science text comprehension. The study taught students several types of text structure that are used in college chemistry textbook: generalization, enumeration and sequence, and classification. While training students how to discriminate among and use text structures found in the textbook with an instructor during each session, the study also asked students to complete their own worksheet after they read the paragraphs. Moreover, the worksheet required students to write the main idea, to list and define the key words of main idea, to restate the main idea, and to list supporting evidence.

Participants were 27 college students, with 17 in the treatment group and 11 in the control group (Cook & Mayer, 1988). Students in the control group participated in regular lab work, and those in the reading treatment group took about 8-9 hours of training in practicing their knowledge of text structure. Students' performance on reading comprehension was measured using a researcher-designed instrument before and after the training.

To measure reading comprehension, students were required to read a passage exemplifying generalization, enumeration, and sequence structures, respectively, on the topic of biological science, and then to complete eight literal questions, four application questions, and the recall of each passage at both pretest and posttest (Cook & Mayer, 1988). An example of the literal questions based on "Digestion" passages was, "what is the length of the small intestine in feet?" For application questions, the study required students to use the text information to generate or infer something new. Moreover, the study scored the recall tests based on idea units, which were categorized into high conceptual and low conceptual information.

The results indicated that the treatment group showed 30% pretest-to-posttest gain for high conceptual information, while the control group showed the reverse trend by gaining 0% for high conceptual recall (Cook & Mayer, 1988). This result indicated the significant difference in processing high conceptual information between students with and without training. Moreover, additional results indicated that trained students were superior in answering comprehension questions; they showed statistically significant improvement on both application and literal questions after the training, with $F(1,16) = 4.54$, $P\ 0.05$. These findings suggest the effectiveness of teaching text structure to college students.

However, it is difficult to rule out other interpretations of the results because the comparison group did not receive the equivalent reading assignment (Cook & Mayer, 1988).

Therefore, the superiority of the treatment group over the control group could be due to the intensive exposure to the reading materials rather than the reading strategy instruction itself. It would be necessary to design a comparison group of students who learn similar materials but do not receive the text structure strategy instruction and thus compare the post-training performance between two groups.

Another study that involved training college students text structure using knowledge map also indicated its effectiveness in improving reading comprehension (Holley, Dansereau, & McDonald, 1979). Focusing on three types of structure: hierarchies (type/parts), chains (lines of reasoning/temporal orderings/ causal sequences), and clusters (characteristics/definitions/ analogies), the study taught students the strategies of using network or concept map to organize information of various passages. The students received six sessions of training and testing in total. The first session introduced the mapping/networking strategy to the students. During the second to fourth sessions, the study mainly focused on the practice of applying strategies to passage reading. The last two sessions were the testing sessions. Students applied their knowledge of the mapping strategy into 500-1000-word passages first and authentic passages from their psychology textbook later. In the fifth session, students were given a 3000-word passage from a geology textbook to study, and they were tested in the sixth session about that passage. In addition to the practice of strategies of text structure during the class, the instructors also provided feedback to the students by the end of each session.

The study recruited 38 college students from a general psychology class to participate in the training, where 17 were in the treatment group and 23 were in the control group (Holley et al., 1979). All students received a researcher-developed comprehension test after 5 days of the intervention (in the sixth session of the study). The study measured comprehension on four types

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of tests, including multiple-choice, short answer, essay, and a summary-oriented concept cloze to the geology passage they studied in the last session. The results of the study indicated that when students were trying to create their knowledge map by applying their knowledge of the text structure, they performed much better than the control group on reading comprehension associated with the understanding of main ideas, with t (36) = 1.91, $p<0.03$.

However, Holley et al.'s (1979) study is flawed in several measures. The first flaw is the lack of the comparison of pre-training ability between two groups. The study did not control any ability level before the training. Therefore, there could be a pre-existing difference in the comprehension skills between those two groups. Another issue is that the control group did not receive any reading training but only took the same posttest, as with the treatment group. Thus, it is hard to attribute the effects of learning directly to the training in organizing information using a concept map.

In conclusion, despite some limitations of those studies conducted during the 1980s, such as the small sample size and a lack of control in the pre-condition, the results of these studies at the college level preliminarily indicated that college students were able to acquire active reading strategies including how to recognize text structure and how to use visual aid to represent text structure to build internal connections from text. The results from these studies also showed that learning text structure could effectively improve students' performance on the recall of text information and reading comprehension. Moreover, both studies described above indicated the positive effects of implicit teaching of text structure to the students in college level, either through the guided questions in training sheets and after-practice feedback or the introduction of text structure before the independent training. However, since both studies were conducted in the early 1980s, the categories of text structure taught during the instruction were very different from

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one to the other: generalization, enumeration, sequence and classification were listed in one study, whereas hierarchies, chains, and clusters were used in the other one. Therefore, it would be valuable to investigate the effectiveness of text structure based on the basic rhetoric patterns of expository texts that were identified by Meyer and her colleagues (Meyer et al., 1980).

There are some unanswered questions in text structure studies with college students. For example, in what subject areas might college students benefit most from learning text structure? Do typically-developing college students actually need explicit teaching of text structure? What kinds of students would benefit most from the direct instruction of text structure? Can college students who are learning foreign language apply their native-language text structure knowledge to reading in a foreign language?

Results from a meta-analysis of text structure. Hebert and his colleagues (Hebert, Bohaty, Nelson, & Brown, 2016) conducted a meta-analysis to evaluate the effects of text structure instruction (TSI). The analysis covered 45 studies involving students from second through 12th grades and examined the effectiveness of text structure instruction on proximal measures of comprehension that included examination of potential moderators and effectiveness for students at-risk or with disability. Furthermore, the study investigated the effectiveness on transfer measures of the effectiveness of the intervention across temporal contexts (maintenance), near-contexts (untaught text structures), and far-contexts (general reading comprehension such as standard tests of reading comprehension). The results indicated that the average effect size on the comprehension measures of text structure instruction was 0.57, which is larger than the average effect size found across educational interventions examining effects on researcher developed measures ($ES = 0.39$; Lipsey et al., 2012). Moreover, Hebert reported that teaching more text structure resulted in significantly larger effects, with 0.13 standard deviation

increase for each text structure taught after the first one. Writing is another significant predictor of the effectiveness of TSI intervention. The study revealed that included writing such as note taking, sentence writing, or writing paragraph-length response resulted in the increase of effect size of 0.38 standard deviation units on average.

When transfer effects were investigated by meta-analysis, the results indicated that text structure knowledge transfers to other contents (Hebert et al., 2016). First, the study found that the effects of TSI transfer across temporal contexts. The significant average effect size for delayed posttest of TSI was 0.57. However, the authors suggested that the effects of TSI maintenance over long periods were still unclear, as the median delay between the posttests and maintenance measures across studies was only 7 days. Second, the analysis of near-transfer indicated a positive transfer from taught structure to untaught structures with an average effect size of 0.62. Last, the study reported a significant average weighted effect size of the far-transfer of general reading comprehension with ES=0.13.

Summary of findings on text structure instruction. Studies on the instruction of text structure generally have positive outcomes and have shown that text structure instruction is effective for various age levels and populations. Previous studies indicated that students from elementary level to college level could all benefit from learning text structure. Strategies of instruction reported in these studies include using schemas, reading/analyzing/discussing passages with clear text structures, learning/identifying/using signal or clue words, using guiding questions, completing graphic organizers, underlining main ideas, and writing/summarizing relevant details. Typically, a range of one to five text structures was covered in each study, and results were generally positive for all structures investigated.

For younger students, an instructional model of teacher modeling, guided practice,

teacher feedback, and independent practice seemed effective. Most studies focusing on elementary students have demonstrated the effectiveness of strategies such as using graphic organizer or identifying the main ideas of learning text structure. Studies at this level usually covered one or two types of structure, such as cause-effect or problem-solution and took 8-12 weeks to deliver the intervention.

For older students, including ones at the high school and college levels, the instruction covered more types of text structure within the similar learning time frame of elementary level students. For example, most studies at high school and college levels had four types of text structure. Another difference at these levels is that, although most studies explicitly taught text structure to students, such teaching only happened at the beginning of the intervention. Students at these levels usually transferred most of their training on applying their knowledge of text structure to reading different types of passages.

By contrast, there are few studies involving students at the middle school level. The only study found in the literature is Meyer's study (Meyer et al., 2010), which delivered instruction through an online system. Therefore, there are still many unanswered questions regarding the effectiveness of text structure at the middle school level, such as effects of explicit teaching in classroom, effects of other reading strategies, and other types of text pattern that were not covered in Mayer's study. Therefore, it is important to extend the findings from young readers and old readers to readers in middle school and to test if explicit teaching of a repertoire reading strategies of text structure can also be beneficial to students at this level.

Outcomes of Reading Interventions in Science Contexts

Many students have found reading scientific texts challenging, as scientific texts often present readers with unfamiliar concepts, new vocabulary, and complex relationships between

ideas (Goldman & Rakestraw, 2000) with a greater density of information per sentence. Therefore, improving students' reading skills of science texts has received a high level of attention recently. From first grade to college levels, researchers have integrated the effective approaches of improving reading comprehension, such as reciprocal teaching, transactional strategy instruction, and text structure strategy instruction, into the science classroom. Moreover, previous studies have demonstrated many significant findings regarding students' achievement of reading comprehension and science learning.

Although the current study focuses on the text structure and its effectiveness to middle school students in reading science text, a search of the literature returned a limited number of studies on this topic. Therefore, this part of the review extends from teaching text structure to students in science learning to teaching reading strategies to students in science learning. Moreover, since students at all school levels, from elementary to college, can benefit from learning science reading strategies, the review of science reading also follows a similar pattern of review of text structure, reporting the important findings from elementary to college.

Science reading instruction for elementary students. Instruction of reading strategy to elementary school students showed positive effects on outcomes of comprehension and science learning. Cervetti and her colleagues (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012) investigated the efficacy of an integrated science and literacy approach at the upper-elementary level. With the attempt to infuse authentic scientific literacy practices into existing inquiry-based science units, the study focused on enhancing learning in both domains. Specifically, the researchers developed a curriculum-based model of science-literacy integration that served both science and reading equally by 1) capitalizing on the knowledge-building context of science for

supporting students' reading comprehension, informational writing, and academic language and 2) enriching students' experiences in inquiry science by reading, writing, and discussion.

In the study, teachers were given a set of materials on the topic of light, and students were engaged in reading texts, writing notes and reports, conducting firsthand investigations, and frequently discussing key concepts and processes to acquire inquiry skills and knowledge about science concepts (Cervetti, et al., 2012). Specifically, reading and writing strategies including making predictions, summarizing, evaluating claims and evidence, and making explanations from evidence were introduced and practiced during the first two lessons of each unit. Moreover, when students moved to deeper learning of content in scientific inquiry activities, they were also asked to apply reading (making prediction) and writing (summarizing, evaluation claims and evidence and making explanations from evidence) to enhance their understanding of science.

The treatment unit was 40 sessions in length and was comprised of four investigations, including the characteristics of light, interaction of light, light and color, and light as energy (Cervetti, et al., 2012). In each investigation, four sessions were devoted to firsthand activities; two sessions to reading; two sessions to writing; and two sessions to discourse, review, and assessment. For the comparison group, the teachers were asked to cover the same topics, which were also required by the state science standard, and to teach those topics in their regular way.

Ninety-four grade-four teachers from 16 school districts in a southern state were recruited to participate in the study and were randomly assigned into a treatment group and comparison group with 47 teachers in each group (Cervetti, et al., 2012). Teachers received the curriculum materials including a teacher's guide, nine nonfiction science books, an investigation notebook for each student, and a kit of materials for students to use in the activities. Moreover, since the study focused on the effectiveness of curriculum, the study only provided materials to teachers

but no professional development. Learning outcomes were measured through a pre-post assessment developed by the Center for Research, Evaluation and Assessment at the Lawrence Hall of Science, covering the domains of science understanding, science writing, science vocabulary, and reading comprehension. The science understanding measure was a 23-item multiple choice test that assessed both the content of the treatment unit and the state science standard. The writing assessment asked students to respond to an open-ended prompt which read, "How does light interact with materials? Give three examples." The scoring rubrics covered seven dimensions: use of evidence, introduction, clarity, conclusion, vocabulary definition, science content, and the use of science vocabulary words. The science vocabulary measure included 15 multiple-choice items – eight of definition matching and seven of cloze. The reading compression test was also a 16-item multiple-choice test that required students to read expository passages and answer the questions.

The data were analyzed with a three-level multilevel model (Cervetti, et al., 2012). The results of the study showed that students in the treatment group made significant gains on science understanding, science vocabulary, and science writing. Specifically, the study indicated that for science understanding, the treatment group scored 1.5 points higher than the comparison group ($p<0.01$), with a large effect size of 0.65. For science vocabulary, the study indicated the treatment group gained 0.75 more than the comparison group ($p<0.01$), with a small effect size of 0.23. In addition, the results showed that the treatment group gained 0.60 more on science writing with a medium effect size, with $p< 0.01$, and ES $= 0.4$. However, the study did not find a significant difference in reading comprehension between the treatment group and the comparison group, suggesting that the further investigation should address more effective reading strategies in science learning.

Focusing on the importance of reading motivation, Guthrie and his colleagues (Guthrie et al., 2004) integrated motivation and cognitive support for reading comprehension of elementary school students in a science classroom. The instruction, called constructed Concept-Oriented Reading Instruction (CORI) provided a science classroom with six reading strategies including activating background knowledge, questioning, searching for information, summarizing, organizing graphically, and structuring stories. Moreover, the study merged reading strategies with many motivational practices of 1) using content goals in reading instruction, 2) providing hand-on activities, c) affording students choices, 4) using interesting texts, and 5) promoting collaboration in reading instruction. Based on such motivational purpose, the program made 124 trade books available to students according to their reading levels, and each student in the treatment was asked to read a total of at least 16 books in the 12-week unit of intervention. In addition, CORI integrated science inquires, such as using existing knowledge, predicting, collecting data, recording, drawing conclusions, and communicating findings as motivation factors into the intervention.

The study recruited 20 third grade teachers to participate in the study, and the students involved in the study were trained with CORI or strategy instruction (SI; Guthrie et al., 2004). SI teachers were taught reading strategies, motivational practices, and planning about the reading lessons, while CORI teachers learned additional information about developing science activities and science-reading integrations. The science content the study covered was "survival of life on land and water" which was divided into two units, "birds around the world" and "the aquatic environment." Six reading strategies were taught in the first 6 weeks, one per week. During the second unit of the next 6 weeks, strategies were systematically integrated with each other.

Students who participated in the studies received a 12-week intervention about CORI and SI, and their performances were compared between the conditions (Guthrie et al., 2004). Pre-post tests on reading comprehension, strategy use, and reading motivation were conducted. Specifically, the study measured questioning, searching for information, multiple text comprehension, reading motivation, passage comprehension, organizing information, and a composite of strategies. The questioning measure asked students to write down as many questions as possible for the passage they would read. The searching for information measure asked students to select the topics for further reading based on the given goals. Multiple text comprehension was an open-ended writing measure, asking students to summarize the main information from the texts. The passage comprehension was a rating task, which required students to rate the relatedness of word pairs drawn from the passage. The composite of strategies combined three strategies--activating prior knowledge, searching, and questioning-- together. The results of the study indicated that CORI students scored significant higher than SI students on multiple text comprehension with $F(1,6) = 6.31$, $p= 0.05$, passage comprehension of $F(1,6) = 8.11$ and $p < 0.03$, the reading strategy composite with $F(1,6) = 6.74$ and $p=0.04$, and the reading motivation composite with $F = 12.17$ and $p<0.02$. Moreover, the study indicated that all the measures had a large effect size range from 0.98 to 1.32. However, the study was analyzed at the classroom level; therefore, the individual differences among students were not taken into the consideration of data analysis. Further study should apply the hierarchy linear model for data analysis.

Science IDEAS (Romance & Vitale, 2012) is also an effective interdisciplinary instructional model linking science and literacy for K-5 students. The model integrated science and literacy in six elements, including hands-on investigation, reading, journaling/writing,

propositional concept maps, application activities, and prior knowledge/cumulative review, to provide students with conceptually coherent and in-depth science instruction. Due to its application to multiple grade levels, Science IDEAS did not have a specific curriculum besides an established curriculum framework that was provided to teachers during their 2-week professional development in the Summer Science Institute. Teachers worked with researchers to develop their own curriculum plans incorporating the basic six elements of science and literacy integration. Results from multiple-year Science IDEAS programs have been reviewed and the effectiveness of the model in engendering students' science and reading achievement growth in grades K-2 were investigated. In addition, for grades 3-5, the study found that teaching students using science IDEAS facilitated positive transfer to learning in grades 6-8, in addition to the immediate effects on science and reading. However, since the Science IDEAS program provided no explicit curriculum for teachers, it would be important to develop direct instruction for teachers and to test the effectiveness of the specific strategies for reading comprehension and science learning.

Several studies have also demonstrated the effects of embedded reading instruction on primary elementary grade students' learning of science. Focusing on secondary grade students' learning of science, Franco-Castillo (2013) investigated the impact of dialogic teaching on science comprehension based on the framework of the Transactional Strategy Instruction (TSI). In this study, teachers were trained with metacognitive reading strategies using Schraw's Strategy Evaluation Matrix, which covered strategies of activating prior knowledge, skimming, slowing down, mental integration, and creating diagrams. In addition, a handbook of Schraw's Strategy Evaluation Matrix was provided to teachers after the training as their scaffolding tool.

During the experimental phase, 39 second-grade students participated in the dialogue journal intervention (DJI), which asked them to complete a journal using a metacognitive graphic organizer during each class after they read and discussed the science book of the day (Franco-Castillo, 2013). After the completion of the journal, teachers reviewed the journals and provided feedback to each student using metacognitive strategies to scaffold clarification of misconceptions and misunderstandings of the text.

The intervention spanned 38 weeks, and students' performance on reading comprehension, science achievement, and metacognitive function were assessed before and after the intervention (Franco-Castillo, 2013). Compared to students who attended the regular science class, the results of the study indicated that DJI students outperformed in their reading comprehension when they were tested using the Florida Assessments for Instruction in Reading. In addition, students' awareness of metacognitive strategies, assessed using the Metacognition Strategy Index, also showed significant improvement after they were trained with the DJI. Science achievement was also evaluated using Scott Foreman science chapter tests, and the results showed that DJI students scored significantly better than the students in the comparison group. Overall, the quasi-experimental study showed the effectiveness of implementing metacognitive reading strategies during science instruction.

Text structure strategy training is another effective approach to improve second graders' reading comprehension of science. Developed by Williams and her colleagues (Williams et al., 2005), the study trained at-risk students to read compare-contrast text using reading strategies in their science class. By comparing different animals that they learned about in their science class, students were trained using text structure strategies including using clue words to identify the structure of text, using a graphic organizer to reorganize important information from the text and

using compare-contrast questions to write a summary about the passage they were reading in the class.

Students learned about one pair of animals during each lesson (Williams et al., 2005). They first read science books about animals and then discussed animals and new vocabulary words from the books in the whole class. After that, they learned the reading strategies for text-analysis of compare-contrast passages, graphic organizers, and summary writing. These strategies were always first modeled by teachers in the whole class and then practiced by students in their independent work. Nine lessons were delivered during 15 sessions among 16 classrooms, and the effects of the intervention were compared among three random assigned groups– a text structure group, a content group which received the same content about animals but no reading strategy, and a no treatment group. The study measured students' reading comprehension, text structure knowledge, and writing. Both the reading comprehension and writing comprehension were measured by recalling important information from the passages.

The results of the study indicated that explicit teaching of reading instruction in second grade improved the ability to comprehend compare-contrast paragraphs (Williams et al., 2005). Students in the text structure group scored significantly higher in their strategy knowledge and oral and written comprehension of texts than students in the other two groups. The treatment students also demonstrated their ability to transfer reading skills into unfamiliar compare-contrast texts. In addition, the study found that the text structure instruction did not detract from students' ability to learn new content, as students in the text structure program demonstrated no significant differences in content outcome measures from students in the content-only comparison program.

The Individualizing Student Instruction in Science (ISI-Science) developed by Connor and her colleagues (Connor, Kaya, Luck, & Toste, 2010) has also demonstrated its positive effect on second graders' reading ability and science learning. That study took advantage of the 5-E Learning Cycle (engage, explore, explain, elaborate, and evaluate) to involve students in inquiry-based activities, class discussion, and use of expository text. Reading strategies including using graphic organizers and writing procedure texts were explicitly taught during the 5-E cycle. Moreover, the study individualized the lessons in three steps. The first step was to group students into levels three to six based on their oral reading fluency. The second was to individualize reading materials using leveled texts. Last, students' scientist notebook was also adapted based on their levels, with the expectation responses to the questions in worksheets varying according to students' reading level.

The study recruited 87 at-risk second-grade students (half of them lived in high-poverty homes), and all of them were in the treatment group (Connor et al., 2010). The study covered five topics related to soil, earthworm, plants, and erosion. Each topic used a 3-6 day format to complete one 5E cycle. Students' performance in science and writing were assessed before and after the intervention using researcher-developed measures. The science test covered 12 multiple-choice questions and three open-ended questions on target content. Moreover, students' writing ability was also measured using their responses to the open questions, and their writing quality was assessed using the number of sentences, the number of words spelled correctly, and the number of multisyllabic words used.

The results indicated that students' understanding of science content was significantly increased during the posttest, with overall $p < 0.004$ (Connor et al., 2010). The results of the study also suggested that students' writing quantity and quality were significantly improved from

the pretest to posttest, with $p < 0.05$. Therefore, the study demonstrated the success of developing and implementing a second-grade science curriculum that supported students' science and literacy learning. However, it is difficult to claim the effects of the 5E instruction since the study did not include a control group in the experimental design.

In summary, interventions at the elementary level that integrate reading into science content were developed based on many different perspectives, including reading motivation, inquiry of science learning, individualizing, text structure, dialogue learning and teacher's professional development. All of the studies reviewed above have shown the promising effects of teaching both reading and science in elementary classrooms. In addition, for those studies that incorporated several effective reading strategies in science classroom, including summarizing, conceptual mapping, questioning, text structure, evaluation and explanation, metacognitive strategies and activating prior knowledge, their results demonstrated the improvement of reading comprehension and writing ability. Moreover, some studies also indicated the improvement of science learning with the integration of instruction. However, since science learning is becoming more complex in secondary school, it is important to investigate the effectiveness of similar programs at the middle school and high school level.

Science reading instruction for middle school students. Reading instruction was also embedded in middle school science learning and showed positive effects on reading comprehension and science learning. Spence and his colleagues (Spence et al., 1999) developed reading instruction that explicitly taught reading strategies in science class to seventh-grade students. The reading strategies that were taught during the intervention were 1) using surface text structure and organization such as the layout of the text, titles of the sections, and visual aids of the texts; 2) accessing prior knowledge, setting purpose, and monitoring comprehension; 3)

understanding word meaning through context; 4) identifying main ideas; and 5) summarizing text. During each science lesson, the teacher-researcher reviewed the reading strategies that were taught in previous lesson and then introduced a new strategy to students, by modeling how to use the strategy first and then asking students to practice the strategy individually or in pairs. Moreover, reading strategies were explicitly taught during the first 6 weeks of the intervention and were continuously implemented in practices in the class during the remaining 14 weeks of intervention.

The intervention spanned 22 weeks among 27 seventh grade students from a regular class, and students' metacognition (awareness and self-management) and comprehension of science text were assessed before and after the intervention (Spence et al., 1999). Metacognitive awareness was measured by the Index of Science Reading Awareness (ISRA), metacognitive self-management was measured by an objective test based on ISRA design, and science reading comprehension was measured using a researcher-developed test that asked students to read passages and answer open-ended comprehension questions. Students' responses to these questions were scored as correct or incorrect based on the scoring rubrics. The results indicated that students achieved significant gains on both metacognition and their abilities to comprehend science text across all reading abilities, with $p < 0.001$. However, it is difficult to claim the effectiveness of the instruction, since the study did not compare the results between the groups with and without the training.

The reading infusion instruction is another approach developed by Fang and Wei (2010) to improve middle school students' science literacy. The researchers developed an instructional technique called inquiry-based science plus reading (ISR) that contained explicit instruction in reading strategies during each lesson for about 15-20 minutes and encouraged students to read

one science trade book every week at home for a year. The study explicitly taught students selected reading strategies including predicting, thick and thin questioning, concept mapping, morphemic analysis, recognizing genre features, paraphrasing, note taking, and think-pair-share, using an explain-model-guide-apply model. Besides teaching of reading strategies, a home science reading program was designed to expand students' reading activity with their family members. During the study, students were required to share one book with their family members, complete a reading response sheet, and answer questions such as "what was the one big idea they learned from the book and one thing they wondered about after reading" after the reading.

The study recruited 233 six- grade students to participate in the intervention over one academic year (Fang & Wei, 2010). One hundred forty students received the ISR instruction, and 93 students received the inquiry-based only (IS) curriculum during their science classes. The science curriculum was developed by the researchers and the teachers that were involved in the study based on the textbook *Science Voyages: Exploring the life, Earth and Physical Science* (Glencoe, 2000). Students' performances of reading comprehension and science learning were assessed after the intervention. Reading comprehension was measured using the GMRT for grade 6. Science literacy was assessed using a curriculum-referenced science test (CRST) that was developed by the researchers and teachers. The CRST consisted of 25 multiple-choice items and covered the nature of science, physical science, life science, and earth and space science. In addition, students' academic year science grades (AYSG) were also reported on a 100-point scale and analyzed.

The results of the study indicated that ISR students significantly outperformed their IS peers on all measures, including the GMRT, the CRST, and the AYSG (Fang & Wei, 2010). Specifically, the study found that the ISR students outperformed the GMRT on both vocabulary

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(ISR group, M = 30.36, SD = 8.62; IS group, M = 26.08, SD = 9.75, $p < 0.01$, ES = 0.23) and comprehension (ISR group, M = 36.00, SD = 8.16; IS group, M = 31.56, SD = 9.72, $p < 0.01$, ES = 0.22). In addition, the study indicated that the ISR group scored significantly higher on CRST (ISR group, M = 13.08, SD = 4.54; IS group, M = 10.83, SD = 4.9, $p<0.01$, ES = 0.35). For AYSG, the study also demonstrated the better performance of the ISR group, with a mean of 79.75 and SD of 11.69, compared to the IS group with a mean of 74.88 and SD of 13.31($F_{(1, 210)} = 6.78$, $p = 0.01$ and ES = 0.34). These results demonstrated the effectiveness of inquiry-based science instruction with infusing explicit reading strategy and the home science reading program. However, since the current study analyzed the results at an individual level, it would be necessary for further study to analyze the results at multiple levels, taking the school, class, and individual into consideration.

In summary, instruction that integrated reading and science showed positive effects on improving both aspects at the middle school level. Reading strategies including prediction, questioning, summarizing, conceptual mapping, self-explanation, and surface text structure analyzing have been incorporated in these studies and have demonstrated their effectiveness in helping students comprehend science texts. Studies also indicated that students could improve their understandings of science when they were explicitly taught reading strategies in their science classroom.

However, compared to the large body of studies on science reading at the elementary level, such studies at the middle school level are limited. Therefore, there are many open questions that need further investigation. The first question is whether reading instruction would help students learn science. Many studies at the elementary level have reported that learning reading strategies can help students improve their learning of science. However, at the middle

school level, such an effect is not clear. The Spence et al. study (1999) reviewed above didn't show the relationship between reading instruction and science learning. Fang and Wei's (2010) study included two sections in the reading intervention; one was the explicit teaching of reading strategies, and the other was the infusion of home reading. Even though Fang and Wei's study emphasized the improvement of the science learning, the effects of direct reading instruction in science learning is still unclear as such effectiveness could be caused by either direct instruction or the infusion of home reading.

Another interesting point at the middle school level is the importance of text structure on comprehending science text and learning science. The knowledge of text structure in comprehending complex text has not received sufficient attention in most studies of science reading, especially the importance of the rhetorical relationships among the important information in a science text. Therefore, it is important to examine if the application of text structure knowledge could benefit students in comprehending science text and thus help them learn science content at this level.

Science reading instruction for high school students. Reading instruction integrated into high school science classes has also showed positive effects in improving students' science literacy as well as their science performance. Reading Apprenticeship (RA), developed by Greanleaf and her colleagues (Greenleaf et al., 2011), integrated metacognitive inquiry routines into science instruction to make explicit the tacit reasoning processes, problem-solving strategies, and textual features that shape literacy practices in academic disciplines. Since little direct instruction has been found at this level, this professional development instruction and it is effectiveness will be described briefly at this session. This professional development instruction was designed to address teachers' conceptual understanding and practice to create inquiry-based,

collaborative classrooms that actively engage students in metacognitive conversations about reading and learning processes. Integrated with core unites of high school biology study, the RA framework centered on metacognitive conversations, including 1) explicit metacognitive routines of think-aloud, text annotation, and metacognitive logs; 2) collaborative learning using think-pair-share, team reads, reciprocal teaching, request, and jig-saw; and 3) comprehension strategies of clarifying, questioning, summarizing, predicting, visualizing, and word analysis.

The instruction engaged teachers in exploring 1) metacognitive processes involved in reading complex texts, 2) videotapes of metacognitive process interviews with students reading texts, 3) evidence of students thinking demonstrated in samples of students work, 4) videotapes of classroom lessons about integrating the RA instructional approach into context learning, 5) varied types of texts used to represent ideas in the discipline, 6) varied types of texts used to represent ideas in the discipline, 7) knowledge and language demands of the texts, and 8) benefits and potential pitfalls of using specific reading strategies with the subject texts (Greenleaf et al., 2011).

One hundred-five teachers were involved in the program (Greenleaf et al., 2011). Teachers were randomly assigned into the treatment group and the control group equally. The teachers in the treatment group joined 10 days of professional development during the whole academic year – 5 days of training before the intervention, 2 days during intervention, and 3 days after the intervention. Both teachers' knowledge and skills about the integration of literacy and science and students' performances on science and reading were investigated in the study. The teachers assigned into the control group received the training after all the data for the study were collected. Assessments were conducted for both teachers and students.

Greenleaf et al. (2011) evaluated teachers' knowledge and skills using teacher assignments and interviews. By analyzing assignments of teachers' sample lesson materials and student work and interviews with teachers about their implementation of classroom practices, the researchers found that intervention teachers demonstrated increased support for students in science literacy learning and use of metacognitive inquiry routines, reading comprehension instruction, and collaborative learning structures compared to the controls.

Students' performance on science and reading were also assessed in Greenleaf et al's (2011) study. Students' science performances were assessed by the California Standards Test (CST) biology test, and their reading comprehension was measured using the CST English language arts and reading comprehension subtest. The results suggested that students in the treatment classroom performed significantly better on the biology CST, with $p = 0.01$ and a small effect size of 0.28. In addition, the results indicated that the students from the treatment group scored significant better on the English language arts ELA CST ($p = 0.04$, d = 0.23) and reading comprehension CST (p = 0.02, d = 0.24).

In summary, the study indicated that even for high school students, it is important to address reading skills in their science classroom (Greenleaf et al., 2011). Different from the science reading approaches at lower grades that provided direct instruction to teachers, the RA approach trained science teachers with knowledge about how to build students' academic literacy skills and engage students in subject learning. It is, however, important to further investigate the effectiveness of direct instruction for high school students in science reading and identify some of the important reading strategies that would be especially helpful for high school students to comprehend complex science content.

Science reading instruction for college students. Some studies have found that college students could also benefit from learning reading strategies in their college science classes. Cook and Mayer (1988) found that even skilled adult readers have difficulties in sorting passages from science textbooks into categories on the basis of text structure. Therefore, they developed an instructional program to train college students to discriminate the text structure of passages from their chemistry textbook. Students participating in the study were introduced to three types of text structures: generalization, enumeration, and sequence. By having the application of reading strategies in reading science passages, such as identifying the types of text structure and identifying the main ideas and supporting information, modeled for them, students learned reading strategies and practiced those skills with their instructor individually by completing worksheets with three more passages of each type of structure from their chemistry textbooks.

Reading performance was assessed after the training using biology texts (Cook & Mayer, 1988). The results indicated that students who received the text structure training showed gains in recall of high conceptual information and in answering comprehension questions including application questions and literal questions, while the control group showed no substantial gains. Therefore, the authors concluded that training students with these strategies helped them focus on the top-level structure of scientific passages, thereby leading to increased comprehension and retention of information.

Self-Explanation Reading Training (SERT) is another effective approach that was developed by McNamara (2004) to improve students' comprehension of science texts. Focusing on improving students' ability of self-explanation of difficult texts, the study trained college students majoring in psychology and biology with five important reading strategies including monitoring comprehension, paraphrasing, predicting what the text will say, making bridging

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inferences to link separate ideas in the text, and elaborating by using prior knowledge and logic to understand the text.

The SERT training lasted about 2 hours with three phases including introduction, demonstration, and practice (McNamara, 2004). In the first phase, students were introduced to self-explanation and reading strategies and then required to read four texts from a middle school biology textbook. During the second phase, students watched a video about how other students self-explained the text they had just read, and applied their knowledge about reading strategies by identifying the strategies used in the video. During the last phase, the students practiced the skills of self-explanation and reading strategy when they self-explained and read aloud the fifth text in their training.

McNamara (2004) measured the outcomes on reading comprehension and self-explanation quality and found that the SERT training was effective, illustrated by a substantial increase in comprehension and exam scores. Specifically, students' comprehension abilities were assessed by inference questions and text-based questions, and the results indicated that by controlling their prior knowledge, SERT students outperformed the control group in text-based questions. In addition, the study developed a protocol to evaluate self-explanation strategies and found that SERT students perform significantly better on self-explanation. The results also indicated that SERT helped students use logic domain-general knowledge rather than domain-specific knowledge to make sense of the text.

Similar to the SERT study that focused on the effects of self-explanation for deep processing of science text, Linderholm and her colleagues (Linderholm, Therriault, & Kwon, 2014) analyzed how students used reading strategies when they were reading expository texts on electricity and determined that self-explanation was a strong predictor of students' performances

in reading and writing. Therefore, the researchers continued to develop reading instruction integrating a self-explanation reading strategy into the multiple texts to improve comprehension of the science course.

In Linderholm et al's (2014) study, over 118 undergraduate students participated in a 1-hour reading study and were randomly assigned into the self-explanation group, who received a pre-reading instruction about self-explanation of the texts, or the comparison group, who only received the reading assignment. Comprehension of the texts and memory of the important information from the texts were assessed by a short-essay comprehension test after students read three articles about electricity. The results indicated that students who received the self-explanation instruction scored significantly better in overall comprehension than the students who did not receive the instruction. Moreover, the study indicated that the self-explanation instruction also improved the accuracy of the understanding of the science concept.

Different from the previous two studies, which taught students the strategy of self-explanation in science reading in a short period of time, Huffman and her colleagues (Huffman, Liu, & Perin, 2015) integrated the reciprocal teaching of reading strategies into an introductory biology course for community college students. In this program, students were explicitly taught the metacognitive knowledge and reading techniques of reciprocal teaching during the first 4 weeks of the biology course. The strategies and techniques that were taught at the beginning of the program included summarizing the main ideas, formulating questions, and clarifying vocabulary, in addition to the biology content covered by the course. Students practiced these skills in the class with their partners as well as in their independent reading homework assignments for each lesson. Moreover, the skills were reinforced throughout the rest of the class as the teacher provided the reading guides for each unit of the instruction.

Huffman et al. (2015) evaluated biology content knowledge (BCK) both immediately after the intervention and at the end of the semester, and the results were compared with the other two sections of the class without reading instruction. The researchers found that students who received the instruction scored significantly better in BCK than the students in the comparison group. However, the study found that students' performance was not significantly different by the end of the semester, although students who received the intervention did slightly better on the posttest. However, the study did not measure students' performance on reading comprehension, which is also worth paying attention to in future study.

In summary, it is also important to integrate reading comprehension skills in college science classrooms. The Studies reviewed above indicated that both of the self-explanation approach and reciprocal teaching approach were effective integration instruction for college students to learn science while developing their reading ability.

Summary of findings on science reading instruction in academic settings. The studies reviewed above all demonstrate the effectiveness of teaching reading comprehension strategies in science contexts. From the elementary to college level, studies indicated that when reading strategies were embedded in science content, no matter whether it was physics, chemistry, or biology, both reading ability and learning of science were improved after the intervention. These studies have demonstrated many effective reading strategies including predicting, identifying the main ideas, using of graphic organizer, collaborating with others, summarizing, identifying the text structure, and self-explanation. For most studies, it was shown that instructional models with teacher modeling, guided practice, teacher feedback, and independent practice are generally effective. Moreover, some studies have shown the effectiveness of professional development in the integration reading and science.

However, it is worth noting that there is a considerable lack of effective integration of instruction at secondary level. First, it is widely recognized that even skillful reading at early grade levels will not automatically transfer into higher-level academic literacy (Lee & Spratley, 2010; Snow, 2002). Second, as students move up the grade levels, especially when they enter the secondary level, text complexity increases, and the uses and features of texts vary from subject to subject. For example, students may encounter many more science texts with new vocabularies and unfamiliar yet condensed content every day in their science class. Therefore, for students at this level, reading comprehension requires a growing set of skills that are situated in particular texts and reading tasks. Consequently, it is important to investigate the effectiveness of reading strategies that are specifically designed for helping secondary school students read science texts and improve their learning of science content.

In addition to the importance of addressing more instruction that combines both reading comprehension and science learning at secondary level, it is also valuable to investigate the effects of text structure in improving reading and learning. Learning science always involves students understanding the patterns of facts and phenomena and analyzing the relationships behind those facts and phenomena; therefore, it would be worth examining how the knowledge of text structure can help students process information at a deeper level and help them determine the relationships between science factors.

Reading Comprehension Instruction for Native Mandarin Speakers

Reading instruction for native Mandarin speakers in Mainland China. Based on cognitive information processing models, especially Kintsch's (Kintsch, 1988) construction-integration model of text comprehension, some studies have indicated the promise of teaching reading comprehension strategies for native Mandarin Speakers. However, when searching the

literature on the Chinese database CNKI using key words such as reading comprehension instruction, Mandarin, and empirical study, the results showed limited studies on the topic. Therefore, this section reviews most of the studies about teaching reading comprehension strategy in Mandarin in Mainland China as well as important studies that conducted in Mandarin in Hong Kong and Taiwan.

In Mainland China, several studies have investigated the effects of teaching reading strategies and showed the promising results of teaching reading strategies. D. Zhang and Yu (1998) conducted a study to train eighth-grade students about the text structure strategy. The study taught students how to recognize the structure of an expository text and how to write a summary with their knowledge of text structure, although the specific types of text structures were not indicated in the study. Students' performance on reading comprehension was measured using a test that was developed by researchers. Moreover, awareness of text structure and the recall of the texts were also measured in the study. The results suggested that students in the treatment group showed a significant improvement on information retention and reading comprehension than the students in the control group. Additionally, the study found that such improvement has no significant difference among different levels of reading ability. These findings all indicated the effectiveness of teaching text structure to Mandarin speakers in China. However, the interpretation of the results could be arbitrary since the study did not report any detailed information about the intervention for the treatment group and the training for the control group.

Another study that was also focused on text structure trained eighth grade students to read expository texts using graphic organizers (Liu & Sun, 2004). By training students on the text structure of three subgroups of listing, including main idea-detail, detail-conclusion, and main

idea –detail –conclusion, the study taught students to use graphic organizers in reading expository texts. However, detailed information about the intervention was not reported in the study. Four regular classrooms were recruited to participate in the study and were randomly assigned into three conditions. For the first condition, the students received the regular reading lessons with reading strategies embedded and completed during 16 training sessions in 11 weeks. For the second condition, the students received the intensive training that had the same lessons with the first condition but finished the training program in 4 weeks. The third condition was the control condition. The self-developed pre-and-post test was used to measure students' performance on reading comprehension, top-level information retention, and reading speed.

The results of Liu and Sun's (2004) study showed that compared to the control group that only received the regular reading lessons of the expository text, both experimental groups gained a significant improvement in top-level information retention, total score on the reading comprehension text, and reading speed. Moreover, the study classified all of the participants into three levels according to their reading ability. The results indicated that while three levels of students showed similar improvements in top-level information retention and the standard test of reading comprehension, the top two levels of students also grained significant improvements in reading speed. In addition, the study examined whether students were able to transfer their knowledge of reading strategies learning from the training of expository texts into other genres of texts, including narrative and argumentation. The study suggested that the group who received the regular reading training in 11 weeks demonstrated significant transfer effects. Although the study indicated the primary effectiveness of graphic organizers for middle school students in comprehending expository texts, the study is flawed because of its small sample size at the classroom level and lack of information about the control group.

Similar to Li and Zhang's (2004) study reviewed above that focused on graphic organizers, X. Zhang and her colleagues (X. Zhang, Bao, Guan, Yu, & Li, 1999) also investigated the effects of graphic organizers on improving reading comprehension for upper elementary students. Focusing on the application of graphic organizers in comprehending all type of texts including narrative, expository, and argumentative, the study trained the teachers to implement reading strategies including highlighting the important information, summarizing, identifying the main idea, and note-taking into their regular class teaching of literacy. The study took place among 160 fourth and fifth grade students for one academic year, and students' end of the year standardized test scores were reported and analyzed. The results indicated that students who received the training outperformed on the end-of-year standardized test compared to the students who took the regular reading classes. However, the study is flawed, as many questions were not clarified in the article. For example, the study did not report the statistical results on each measure between groups. Moreover, the teachers involved in the study taught both the treatment class and the control class, which could cause difficulty in interpreting the result.

The effectiveness of metacognitive strategies on reading comprehension has also shown its positive effect on Mandarin speaking students. Focusing on the metacognitive strategy including predicting, questioning, identifying important information, and summarizing, Li (2007) conducted a study among 82 eighth-grade students. The study trained teachers about metacognitive strategies in reading and provided a guide for teachers to implement metacognitive strategies in their daily reading classes. After 2 months of intervention, the study found that students who received the training on metacognitive reading strategies performed significantly better on comprehension tests and their monitoring of metacognitive strategy.

Reading instruction for native Mandarin speakers in Taiwan and Hong Kong. In

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addition to the studies in Mainland China, research from Hong Kong and Taiwan has also demonstrated the effectiveness of reading instruction on students' comprehension in Mandarin. Lau and Chan (2007) developed Chinese cognitive strategy instruction to teach a repertoire of reading strategies to seventh-grade low-achieving students in Hong Kong. Their 32-session reading instruction taught students about four parts of important reading strategies, including 1) macro-rules of signaling, deletion, selection, generalization and construction; 2) Comprehension monitoring strategies of error detection, inferring word meanings and simple fix-it strategies; 3) strategies for comprehending expository text of text structure strategy and summarizing strategy; and 4) strategies for comprehending narrative text of text structure strategy, reciprocal teaching and inference strategy.

Lau and Chan (2007) recruited a total of 88 participants recruited from four Chinese language remedial programs from a Band 3 school, which was classified as a school in the bottom 33% of the Hong Kong school system. Since the remedial programs needed to remain in its original class, the study randomly picked one of four remedial programs as a treatment group and the other three groups as the control group. In addition, the treatment group was involved in a 6-week intervention of Cognitive Strategy Instruction, which was taught by the researcher, while the control group was taught by their teachers using original school curriculum.

Students' performance on reading strategy and comprehension were tested before and after the intervention using the researcher-developed 47-item Reading Strategy and Comprehension Test (Lau & Chan, 2007). The test included two parts; the first part measures students' ability to apply the strategies, including selection, generalization, inferring word meaning, error detection, and summarization. The second part of the Reading Strategy and Comprehension Test measured comprehension on narrative texts and expository texts, which

asked students to finish four multiple-choice questions and two open-ended questions. The study also measured reading transfer, which asked students to read one narrative text for a history book and one expository text from a humanities book and answer 10 open-ended questions about each text.

The results of the Lau and Chan's (2007) study indicated that students in the treatment group were able to use more strategies during their reading process (means 46.9 vs. 37.8), $p<0.01$), present better knowledge of reading strategies, and show a more positive attitude toward reading instruction than their peers who received traditional Chinese language instruction. Moreover, the study showed that students' improvements on their strategy knowledge and reading comprehension ability were maintained in the 4-month delay test. However, although the results of the study showed that the treatment group achieved a better score on comprehension, the difference was not significant statistically. Therefore, it would be important for further investigation to discover the effectiveness of reading strategies on comprehension of Chinese texts for students in Hong Kong schools.

Focusing on the studies in Taiwan where students also learn Chinese as their first language, Hsieh (2015) conducted a meta-analysis about teaching reading strategies to students in grades K-12. The study investigated the important reading strategies including 1) questioning, 2) determining story structure, 3) using graphic organizers, and 4) summarizing and reported that these strategies showed moderate effects with an effect size from 0.35 to 0.6 on improving Chinese students' reading comprehension. Specifically, for the 10 studies on questioning that were selected to be reviewed in this meta-analysis, the results showed that the average effect size was 0.35, and all studies were focused on the students from grade 4 to grade 6. For the story structure, four studies were selected for review, and the average effect size was 0.42. Moreover,

Hsieh reported that all the studies were focused on students from grade 3 to grade 5. Studies on graphic organizers were a large part of this review; it was reported that 16 studies met the criteria and were selected for review. The average effect size for this group was 0.40. The students that these studies involved ranged from grade 3 to grade 8. Moreover, most studies were focused on expository texts. In summary, seven studies targeting students from grade 4 to grade 8 were reviewed, and the average effect size of this group was 0.58. In addition, the study also examined the effect of reciprocal teaching in Chinese. By reviewing 22 qualified research studies, the author found that the reciprocal teaching also had a moderate effect size with 0.50.

Summary of reading instruction for native Mandarin speakers. In summary, the studies conducted with native Mandarin speakers showed similar effects to studies in English. These studies indicated the native speakers of Mandarin could also gain significant benefits from reading instruction including text structure, reciprocal teaching, and Chinese CSI. Results of these studies also suggested that students who received interventions improved their performance in reading comprehension as well as their performance on the standard tests of Chinese language and literacy. However, there are still many issues that need further investigation.

The first issue is that more rigorous studies should be conducted among native Mandarin students, as most previous studies reviewed were flawed in many aspects. For example, many studies were found lacking reporting on their intervention or measures. Without those details it is impossible for researchers and educators to understand how the interventions were conducted and whether the results were convincing. The second issue is to investigate the reading instruction within subjects' contexts. Review of previous studies indicated that most were conducted in language classes, and little was embedded within specific subjects. Therefore, it

will be important to examine the effects of embedded reading instruction in reading science materials.

Discussion and Conclusion

This chapter has reviewed a collection of studies on the teaching of text structure knowledge and strategies for science reading in English-dominant settings, and the teaching of reading strategies in Chinese language settings. Overall, the studies clearly demonstrate that teaching text structure is beneficial to students at various levels, ranging from elementary school to college. The next section of this chapter seeks to answer the questions that guided the literature review and then suggest questions that still need to be answered.

Q1: What is text structure and why it is important in comprehending expository texts? Expository texts are organized in a variety of structures. Classified rhetorically, the basic types of text structure for expository texts include description, sequence, comparison, causation, and problem-solution. Knowledge of text structure plays a crucial role in processing, memorizing, and making judgments during reading, as it can facilitate the identification of important ideas and their memorability. More importantly, it is suggested that utilizing the knowledge of text structure can help students comprehend information from unfamiliar domains. Therefore, learning text structure plays a crucial role in children's literacy development when reading informational texts, and thus the effectiveness of direct reading instruction in text structure for different levels of students should be fully investigated.

Q2: What outcomes have been reported on text structure interventions for improving reading comprehension? Studies on the instruction of text structure generally have positive outcomes and have shown that text structure instruction is effective for various age levels and populations. Previous studies indicated that students from elementary to college levels

could all benefit from learning text structure. Strategies of instruction reported in these studies include using schemas, reading/analyzing/discussing passages with clear text structures, learning/identifying/using signal or clue words, using guiding questions, completing graphic organizers, underlining main ideas, and writing/summarizing relevant details. Typically, a range of one to five text structures was covered in each study, and results were generally positive for all structures investigated.

For younger students, an instructional model of teacher modeling, guided practice, teacher feedback, and independent practice seemed effective. Most studies focusing on elementary students have demonstrated the effectiveness of using strategies such as using graphic organizers or identifying the main ideas of text structure. Studies at this level usually covered one or two types of structure, such as cause-effect or problem-solution and took 8-12 weeks to deliver the intervention.

For older students, including those at high school and college levels, the instruction covered more types of text structure within the similar learning timeframe of elementary level students. For example, most studies at high school and college levels had four types of text structure. Another difference at these levels is that, although most studies explicitly taught text structure to students, such teaching only happened at the beginning of the intervention. Students at these levels usually transferred most of their training on applying their knowledge of text structure to reading different types of passages.

Compared to studies at other levels, there are only a few studies involving students at the middle school level. One of the studies found in the literature is Meyer's (2010) study, which delivered content through an online system. As a result, there are still many unanswered questions regarding the effectiveness of text structure at the middle school level, such as effects

of explicit teaching in classroom, effects of other reading strategies, and other types of text pattern that were not covered in Meyer's study. Therefore, it is important to extend the findings from young readers and teen or young adult readers to readers in middle school and to test if explicate teaching of a repertoire of reading strategies of text structure can also be beneficial to students at this level.

Another important issue that should be addressed is integrating the content in the text structure instruction. Except for the Williams (2005) study that focused on second grade science and social studies and the Cook and Mayer (1988) study that focused on undergraduate science, most of the studies conducted their interventions in general reading classes and have not addressed specific content area. Therefore, it would be important to investigate the effectiveness of text structure instruction in specific content, especially in science.

Q3: What outcomes have been reported on reading comprehension interventions using science texts at the elementary, secondary and postsecondary levels? The studies reviewed above all demonstrate the effectiveness of teaching reading comprehension strategies in science contexts. From elementary to college levels, studies indicated that when reading strategies were embedded in science content, no matter if it was physics, chemistry or biology, both reading ability and learning of science were improved after the intervention. These studies have demonstrated many effective reading strategies including predicting, identifying the main ideas, using a graphic organizer, collaborating with others, summarizing, identifying the text structure, and self-explanation. For most studies, it was shown that instructional models with teacher modeling, guided practice, teacher feedback, and independent practice are generally effective. Moreover, some studies have shown the effectiveness of professional development in the integration of reading and science.

However, it is worth noting that there is a considerable lack of effective integration instruction at the secondary level. First, it is widely recognized that even skillful reading at early grade levels will not automatically transfer into higher-level academic literacy (Lee & Spratley, 2010; Snow, 2002). Second, as students move up the grade levels, especially when they enter the secondary level, text complexity increases and the uses and features of texts vary from subject to subject. For example, students may encounter many more science texts with new vocabularies, and unfamiliar yet condensed content every day in their science class. Therefore, for students at this level, reading comprehension requires a growing set of skills that are situated in particular texts and reading tasks. Therefore, it is important to investigate the effectiveness of reading strategies that are specifically designed for helping secondary school students read science texts and improve their learning of science content.

In addition to the importance of addressing more instruction that combines both reading comprehension and science learning at secondary level, it is also valuable to investigate the effects of text structure in improving reading and learning. Learning science always involves students understanding the patterns of facts and phenomena and analyzing the relationships behind those facts and phenomena; therefore, it would be worth examining how the knowledge of text structure can help students process information at a deeper level and help them determine the relationships among science factors.

Q4: What reading comprehension interventions have been reported involving Mandarin-speaking participants? The studies conducted with native Mandarin speakers showed similar effects to studies in English. These studies indicated the native speakers of Mandarin could also gain significant benefits from reading instruction including text structure, reciprocal teaching, and Chinese cognitive strategy instruction. Results of these studies also

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suggested that students who received the interventions improved their performance in reading comprehension as well as their performance on the standard tests of Chinese language and literacy. However, there are still many issues that need further investigation.

The first issue is that more rigorously studies should be conducted among native Mandarin students as most previous studies reviewed were flawed on many aspects. For example, many studies were found lacking detailed reporting on their intervention or measures. Without these details it is impossible for researchers and educators to understand how the interventions were conducted and whether the results were convincing. The second issue is to investigate the reading instruction within subjects' contexts. Review of previous studies indicated that most were conducted in language classes and few was embedded within specific subjects. Therefore, it will be important to examine the effects of embedded reading instruction in reading science materials.

Implications of the available research. Despite the wide range of topics covered in the currently-available studies, there are still many unanswered questions and missing pieces regarding teaching text structure. Those questions need to be addressed in order to obtain a better understanding and developing a better strategy for enhancing science reading in Chinese settings.

First, there is a lack of studies conducted at the middle school levels, both in teaching text structure and strategies in science reading. A thorough literature review of the text structure instruction showed that most studies focused on the elementary level (both primary and upper elementary levels), while only a small fraction of studies focused on the middle school level. These previous studies have demonstrated that reading strategies, including questioning, graphic organizers, and summary writing, are effective in teaching all five basic types of text structures to elementary students. However, these positive effects are not fully tested for students at the

middle school level who are still facing significant challenges in reading expository texts. Similarly, most studies on science reading reviewed in this paper focused on elementary level and college level. This gap in the research could hinder the development of effective instruction for high school students who are also still facing significant challenges in reading expository texts while also gaining increasing exposure in science texts. Therefore, further studies at this level are needed in order to better help students comprehend information contained in science texts.

Second, it is crucial to integrate the text structure into the science context. Studies on reading instruction of science texts have demonstrated the effects of improving the understanding of science texts using many powerful intervention-based approaches including concept-oriented reading instruction, dialogue journal intervention, individualizing student instruction, inquiry-based science plus reading, self-explanation reading training, and reciprocal teaching. While most interventions studied did involve some elements of text structure, only one study explicitly taught the text structure to second grade students. Therefore, it is important to further examine the effectiveness of text structure within science contexts, particularly how students can utilize the knowledge of rhetorical structure of text to help them comprehend science texts at a deep level.

Last but still importantly, it is also essential to investigate the effect of reading instruction for native speakers of Mandarin. Review of the literature showed that few research-based reading comprehension instructional programs were developed in Mandarin for students in Mainland China. Therefore, it is crucial to extend the benefits of reading interventions that have been studied with English speakers to Mandarin speakers. In particular, it is important to investigate the effects of text structure instruction in helping students reading science texts in Mandarin.

Research question for the current study. Based on this literature review and the research gaps identified, the current study focuses on Mandarin speaking middle school students in Mainland China and aims to learn whether Mandarin-speaking students who participate in a text structure intervention using science texts can gain knowledge of text structure of both 1) science texts and 2) generic texts, as well as demonstrate better performance on the following three aspects:

1. Comprehension of science texts;

2. Comprehension of science texts;

3. Standardized reading comprehension tests.

CHAPTER III

METHOD

Participants

The participants were a group of sixth graders attending a top-ranked private school in Chengdu, one of the largest metropolitan areas in China. The school teaches students from kindergarten to the twelfth-grade. Each year, over 80% of its graduates are admitted to the top 100 universities in China, and its high school is ranked among the top ten high schools in the city. The majority of school's students come from middle-class families, and all of them speak Mandarin as their native language.

A total of 90 participants were recruited to the study, 53 of whom were male and 37 female. These students were enrolled in two classes, each of which was taught a teacher who volunteered to participate in the study. Two students were absent during the course of the intervention and were therefore excluded from the study. Thus, the total number of participants in the final data analyses was 88, of whom 51 were male and 37 female. The numbers of students assigned to each condition is shown in Table 4.

Table 4

Number of Students by Condition

Conditions	Number		
	Female	Male	Total
Comprehension Science Text with Structure (CSTS)	19	24	43
Content-only (CONT)	18	27	45

Educational Context: School Setting in China

The formal education system in China consists of two stages, commonly referred to as fundamental education and higher education. Fundamental education has three divisions: preschool, which is for children from aged between 3 to 5, primary school, which is for students from aged between 6 to 11 and secondary school, which is for students aged from 12 to 18 (Flannery, 2018). The schemes used to partition grades into primary and secondary schools varies slightly across school districts. For example, in Shanghai, the sixth grade is called the pre-middle grade and is categorized as being the part of the middle school. In some other cities, including the city of Chengdu where this study was conducted, the sixth grade is considered to be the senior grade of primary school. Despite the formal classification, the sixth grade classes considered in the current study are better to be considered as part of the middle school, as all of the students were enrolled in a special pre-middle-school program and exempt from the middle school admission process. All of the participants are taught using the pre-middle school curriculum during their sixth-grade year.

Teaching in the Chinese educational system is subject-based from the first to the 12th grade. Usually, each class is assigned a fixed classroom, with different subject instructors moving from class to class. For example, in the morning, students may receive lessons from their language art teacher, followed by their math teacher and then their science teacher. The class size is fairly large at most schools: According to the OECD report (OECD, 2014), an average class has 37.5 students. A typical school year runs from September 1st to early July of next year, with a month-long winter break for the Chinese New Year in January or February.

Although a rarity in the past, the number of private schools in China has grown tremendously during the last decade in China, especially in big cities across the nation, with an

annual growth rate of approximately 12.1% (Flannery, 2018). According to a report from the Department of City Development of Chengdu, the city in which the main study was conducted, 14.32% of first- to 12th-grade students attended in 2017 (Development & Strategic, 2018). Research suggests that the increasing popularity of private schools among the rising middle class in China is largely due to the fact that private schools can provide more flexibility in terms of curriculum, enrollment, and residential accommodations (Flannery, 2018), and as a result, a higher quality education.

The private school system involved in the study has nine campuses and more than 10,000 registered students. The intervention research was conducted in one of its main campuses, which is located in the downtown of the city and has an enrollment of approximately 4500 preschool to 12th grade students during the academic year of 2017-2018.

Design

To conduct a controlled experiment, the participating students were randomly assigned to one of two groups, the treatment group ($N = 43$) or the control group ($N = 45$). Participants in the treatment group underwent the Comprehending Science Text with Structure (CSTS) program, which was adapted from a text structure intervention designed by Williams and colleagues (2016). In comparison, those in the control condition received content-only (CONT) reading instruction, which used the same reading materials as those provided to the treatment group but without text structure instruction. Each group of students was taught over the course of 15 lessons.

Two six-grade Chinese language arts teachers from the school volunteered to participate in the study and received training from the researcher before teaching the courses. They were encouraged by their principle to become involved in an educational research as a form of their

professional development. Both teachers are female and hold master's degrees in education. They have been teaching the Chinese language at this school for more than 8 years, but have little experience of science instruction.

To minimize the effects of variation between different instructors for different groups, the two teachers were rotated to teach both groups, that is, Teacher A first taught lessons 1–9 in the CSTS group and then switched to teaching lessons 10–15 in the CONT group, while Teacher B did the opposite. The assignment of teachers is presented in Table 5.

Table 5

Teacher Assignment by Condition

Teachers	Lessons 1 - 9	Lessons 10 – 15
Teacher A	Comprehension Science Texts with Structure (CSTS) Program	Content-only (CONT) Program
Teacher B	Content-only (CONT) Program	Comprehension Science Texts with Structure (CSTS) Program

In this study, the independent variable is the instructional condition (treatment vs. control). There are five dependent variables: text structure knowledge of science texts, text structure knowledge of generic texts, science reading comprehension, generic reading comprehension, and scores on standardized reading tests. All measures, with the exception of the standardized reading tests were designed by the author. One of the standardized reading tests was developed by the Shanghai Educational Test Center and is widely administered in China. The independent and dependent variables are summarized in Table 6. The study also utilizes two covariates: one is scores on reading and the other is science tests adopted by the author from measures in the Program for International Student Assessment (PISA) (Lu, 2013; OECD, 2018).

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Table 6

Independent Variable and Dependent Variables of the Study

Independent Variable	Dependent Variables

Instruction
 	
Comprehension Science Texts with
 	
Structure instruction (CSTS)
 	
vs.
 	
Content-only (CONT) instruction
	1. Text Structure Knowledge of Science Texts
	
	    a. Knowledge of Text Structure
	
	    b. GO[a]/generation
	
	2. Text Structure Knowledge of Generic Texts
	
	    a. Knowledge of Text Structure
	
	    b. GO/generation
	
	3. Reading Comprehension of Science Texts
	
	    a. GO/important ideas
	
	    b. Text Summary
	
	4. Reading Comprehension of Generic Texts
	
	    a. GO/important ideas
	
	    b. Text Summary
	
	5. Performance on Standardized Reading
	
	  Comprehension Test
	
	    a. Chinese Reading Comprehension Test
	
	      (CRCT)
	
	    b. PISA Reading Posttest

[a]GO: Graphic Organizer.

Instructional Materials

The intervention materials consisted of teacher handbooks, student handbooks, and the PowerPoint slides presented in each lesson. The teacher's handbook includes the teaching guidelines for each lesson, reading passages, and samples of text analysis of each passage. The student' handbook contains mostly the learning materials of each lesson. All materials were organized by lessons and stapled together in the form of a booklet for teachers and students. The materials were reviewed by the teacher participating in the pilot study and were previously used in the pilot study. Minor modifications were made before the materials were printed and used in this main study.

All materials were developed by the author and were written in Mandarin. The instructional program was developed by the author based on the work of Williams (2016) and was tested in the pilot study described previously in this dissertation. Two major improvements were made based on the pilot study findings, which indicated that the completion rate of after-class homework was too low to justify a reasonable comparison between two groups. Therefore, in the main study, the independent practice, which was part of the assignment originally assigned as homework, was changed to in-class work monitored by the teachers to ensure a higher completion rate. In addition, the duration of program was extended from a five 45-minute lessons in the pilot study to a fifteen 30-minute lessons in the main study. These modifications resulted in an additional 225 minutes of student work in the intervention group in the main study.

Overview of lessons. The CSTS program developed by the author is a 15-lesson reading curriculum, with each lesson lasting 30 minutes. The design of the CSTS is based on the work of Williams and colleagues (Williams et al., 2016), who developed a framework focusing on close

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analysis of texts with structure (CATS) for second-grade students. Previous studies have illustrated that use of these supports and strategies is associated with successful text structure instruction outcomes in terms of reading comprehension on students at different grades (Armbruster, Anderson, & Ostertag, 1987; Ordynans, 2012; Snyder, 2012). Therefore, the CSTS program used in this study adapted several important features of the CATS program including close analysis of texts, together with the use of reading comprehension strategies such as generic questions, graphic organizers and summary writing.

In order to match the level of reading skills of middle-school students, the CSTS program also incorporates an aspect of the design of Meyer's studies, namely the sequence of introducing texts with various complexity levels through multiple sessions (Meyer, Brandt, & Bluth, 1980; Meyer & Poon, 2001). More specifically, the CSTS program first introduces students to short paragraphs with different text structures, followed by long articles. The five types of text structure involved in this study were *Sequence*, *Description*, *Comparison*, *Cause-effect* and *Problem-solution*.

Combining the important features of Williams' (2016) CATS framework and Meyer's (2001) design, the key feature of the CSTS program is to teach students how to use three important reading strategies – Generic Questions (GQs), Graphic Organizers (GOs) and Summary Writing (SW) – to read science texts featuring five types of structure. The specific lesson plan of CSTS program is illustrated in Table 7 and explained as follows.

Table 7

Comprehension Science Texts with Structure (CSTS) Program: Lesson Overview

Lesson	Strategies	Texts Used
L1-L3	Generic Questions (GQs)	Short paragraphs (10)
L4-L6	Graphic Organizers (GOs)	Short paragraphs (10)
L7-L9	Summary Writing (SW)	Short paragraphs (10)
L10-L12	GQs, GOs, and SW	Long paragraphs with single structure (2)
L13-L15	GQs, GOs, and SW	Long paragraphs with mixed structures (2)

In this study, the CSTS program was taught in the students' regular Chinese language arts class. The format of the lesson included teacher's modeling of text structure strategy, group discussion, and independent work by student using the strategies taught in the class. It is important to note that, during the classes, teachers were asked to *explicitly* teach the reading strategies in each lesson. This specific direction was based on the findings of previous studies indicating that explicit instruction is the most effective factor in improving student performance in this area (Atkins, 2013).

The first three lessons focused on the learning of the *Generic Questions (GQs)*. In the first lesson, students were introduced to different types of paragraphs, thereafter, the teacher modeled the use of three GQs to identify the specific type of text structures. These three questions are as follows: 1) What is the main idea? 2) What are the signaling words? 3) How does the author organize the paragraph? For example, the teacher first modeled the application of GQs in analyzing the sequence structure of the short passage, a short passage titled "How Did the Scientists Find the Water on Mars*"*. Thereafter, students worked in small groups and discussed with their partners how to apply the generic questions to a new paragraph with a new

type of text structure. Each group chose from one of four paragraphs provided: "The Effects of Transgenic Technology on Crops", "The Application of Radiation", "Vegetable Oil and Animal Fat", and "How to Deal with Hot Autumn". Each paragraph represented one type of text structure.

After completing the group discussion, each group presented their responses to the whole class. Based on the responses, the teacher then provided feedback to the class regarding each group's usage of reading strategies. Following the group activity, each student was asked to complete a 30-minute individual assignment consisting of a quiz and an additional independent reading. This reading activity involved five more paragraphs, which represented the five types of text structures previously taught in the class. In this session, students reviewed the knowledge of text structure provided during the introductory section of the lesson and tested their mastery thereof by applying the text structure strategy to the five new paragraphs.

Once the students completed the first three lessons in learning how to use GQs to identify the text structure of a passage, they moved to Lessons 4–9 where they were taught how to use *Graphic Organizers (GOs)* and *Summary Writing (SW)*. More specifically, in Lessons 4-6 students were taught how to use GOs to record important information from a text based on its text structure. In Lessons 7-9, students were taught how to use the SW strategy to rewrite important information from paragraphs. Each group of three lessons is considered to be a block as they cover the same reading materials. The teaching pattern was similar for each block, starting with the teacher's modeling, followed by group discussion, and finally independent work. More details of this pattern are demonstrated in *Figure 1*.
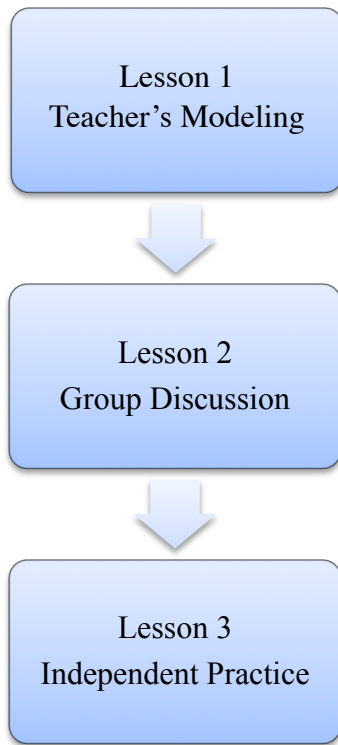
Figure 1. Learning procedure for each lesson block

During the final six lessons of the program, students practiced their newly acquired

knowledge and skills by applying the strategies they had learned from the previous classes to

reading and comprehending long articles. The instruction in Lessons 10-12 involved two long

articles, each of which focused on one type of structures. The teacher first modeled how to

identify the type of article using GQs, followed by students working in groups on GO and SW.

Finally, students worked independently on a new article using GQ, GO, and SW. For last three

lessons, *i.e.* Lessons 13-15, students read long articles involving more than one type of structure,

following the same pattern used in Lessons 10-12.

Samples and templates for learning text structure strategies. For the CSTS program,

samples and templates of how to use those strategies were also provided to students during each

lesson, a design adapted from the instructions from Williams' studies (Williams, Hall, & Lauer, 2005; Williams et al., 2016; Williams, Stafford, & Lauer, 2009).

To be more specific, in Lesson 1, students were given a table that provided the definitions of five types of text structure, introducing the definitions of five types of text structure, namely sequence, description, comparison, cause-effect, and problem-solution, together with signal words for each type. Sample generic questions that can be used to identify and comprehend different text types were also distributed. In addition, students were provided with 10 short science texts to be used during the first three lessons (see Appendix A for the list of texts). In Lesson 4, students were provided with the GO templates for different types of text structures, which were then used to learn how to use GOs to record important information from text based on its structure. In Lesson 7, students were given SW templates containing signal words corresponding to each text structure. Those templates were then used in learning the process of rewriting important information from the paragraphs provided. Examples of GQs, GOs, and SW templates are located in Appendix B.

Science texts. Ten short and four long paragraphs on science-related topics were selected from authentic sources including Chinese newspapers, magazines, and online websites. The topics of the paragraphs and articles range from physics, chemistry, biology, and energy, to life science. All of the paragraphs and articles were reviewed by the Chinese art teachers involved in the main study prior to their distribution to students. The readability levels of the texts were also verified by the teachers as matching the reading ability of middle school students. A list of the short paragraphs and long paragraphs used is located in Appendix A and an example of a short paragraph is provided in Appendix C.

In addition, those 10 short paragraphs were modified by the author to cover the five types of text structure and were then presented in the first nine lessons. The length and complexity of each paragraph vary slightly, as some were longer and more complex than others. Five of these 10 articles – each representing one type of text structure – were used in class for teacher modeling and group discussion, while the remaining five were used for students' individual practice. Those short passages were used in Lesson 1 to Lesson 9.

Four long articles were presented in the last two lessons. Two were used for in class modeling and the other two were used for individual practice. The two long articles used in Lesson 10 to 12 only involved one type of structures: one involved description and the other involved cause-effect. By contrast, those used in Lesson 13 to 15 involved more than one type of structures: one involved comparison, cause-effect, and problem-solution while the other one involved comparison, description, cause-effect, and problem-solution.

Lessons for the control group. For the control group, students received content-only (CONT) reading instruction in the classes that covered the same reading materials as those included in the CSTS program but lacks the text structure component. Similar to the treatment condition, the program for the control condition was also taught by Chinese language arts teachers in their regular Chinese language arts class. The teachers taught and discussed those materials using their traditional methods for teaching students how to read expository texts. The teachers were also encouraged by the author to use class discussion, group discussion, individual reading, class reflection, and other methods in class.

Measures

After the completion of the 15 lessons, the outcomes of students' learning of text structure and their reading comprehension ability were assessed using multiple researcher-

developed measures involving both science and generic texts. Furthermore, the reading

comprehension was additionally assessed using standardized reading comprehension tests.

Researcher-developed tests. Two 45-minute tests were designed by the author to assess

students' knowledge of text structure and their reading comprehension ability. All researcher-

developed tests that were used in this study are located in Appendix D (Chinese version) and

Appendix E (English translation).

Text structure knowledge. Two measures were used to assess students' knowledge of

text structure. The first one assesses text structure knowledge and askes students to name the

primary text structure of each of four stimulus texts. An example of a question used in this

measure is "What is the structure of this text?" The second measure is the generation of the

graphic organizer (GO/generation), which asks students to draw an appropriate GO based on

their knowledge of text structure in the stimulus passage of each of four texts. One example of a

prompt given to students is "Generate a graphic organizer for the passage you just read." Both

measures are open-ended questions and each correct response receives one point. Students were

required to complete two sets of tests, in which the first involved science texts and the other with

generic texts.

Reading comprehension. There were also two measures intended to assess the level of

students' reading comprehension. The first one is the number of important ideas included in the

GO (GO/important ideas). It requires students to include as many important ideas as they can

identify in a GO from source texts. For this measure, the question itself is the same as that used

for the GO/generation. Examples of responses to this question can be found in *Figure 2*.

The second measure is text summary. It requires students to include important ideas in a

written summary for the source texts. One example of the prompts in this measure is "Please

write down the important ideas from the passage." This measure takes the form of open-ended questions that ask students to write a summary of each of the four science texts and the four generic texts that they read. The total number of important ideas in each text varied from 20 to 38. More details regarding this measure are presented in the subsequent Scoring section. The examples of responses from both conditions are shown in *Figure 3*.
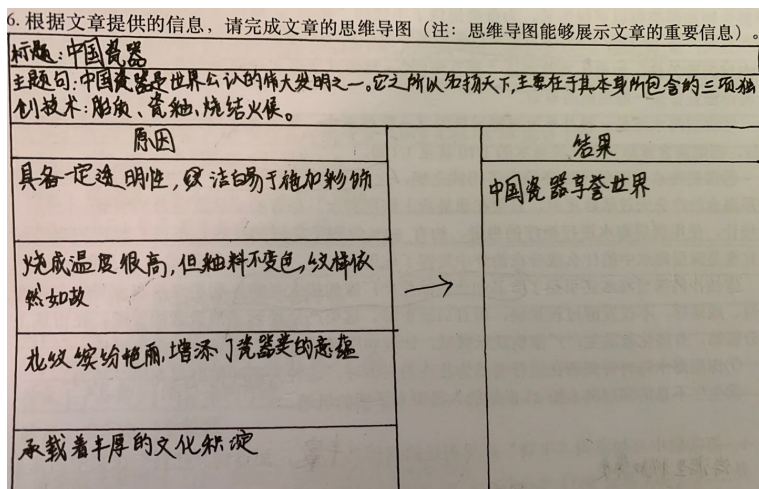
(A)
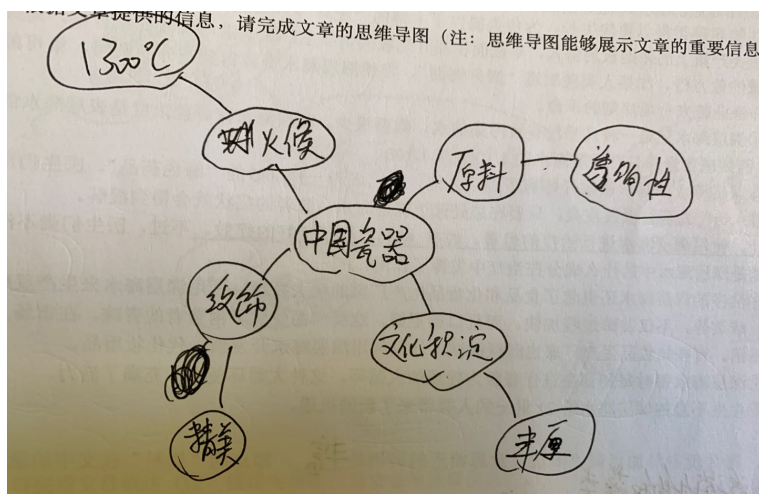
(B)

Figure 2. Students' responses to the generation of a Graphic Organizer (GO) for the generic text "Chinese Porcelain". (A) An example of a response from a student receiving the text structure program; (B) an example of a response from a student receiving the content-only program.
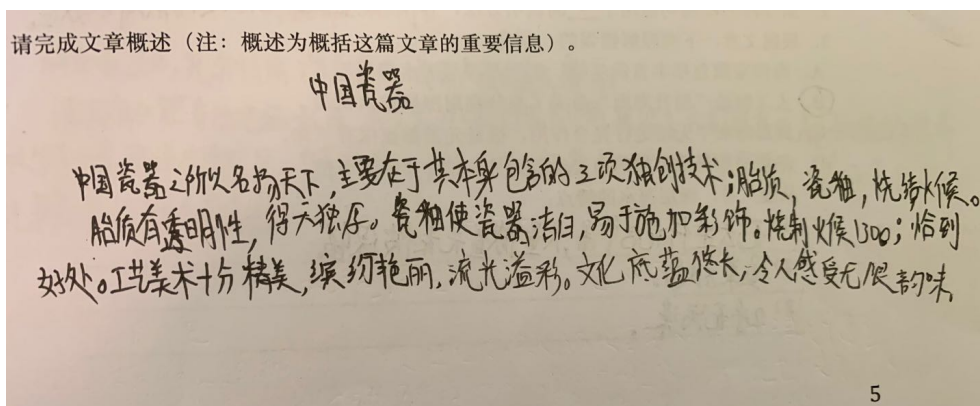
(A)
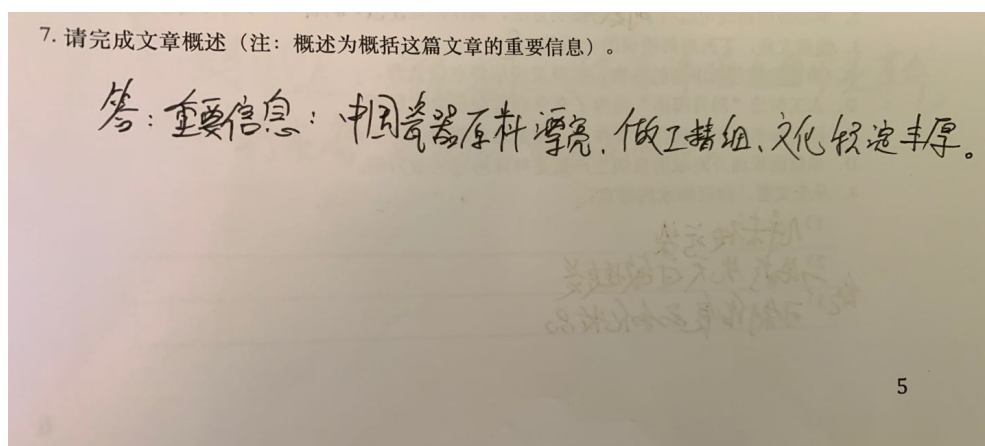
(B)

Figure 3. Students' responses to a text summary of the generic text "Chinese Porcelain". (A) An example of a response from a student receiving the text structure program; (B) an example of a response from a student receiving the content-only program.

The authors developed two sets of tests to measure both the text structure knowledge and comprehension: one focuses on science texts and the other focuses on generic texts. They were designed based on the work of Williams (2016).

For the first test set, students were required to complete a reading task involving four science texts. Those science texts, which were consistent with the students' reading ability level, were selected to measures students' comprehension of science texts. Two of the texts,

"Diabetes*"* and "Pain", were selected from a seventh-grade biology book (Kang Hsuan, 2006) and registered readability levels of 6.68 and 5.44, respectively. Those two texts were shorter in length and less conceptually dense. The other two texts, "Light for Plants" and "Habitation on Mars", adapted from a science magazine for middle school students, had readability levels of 7.43 and 7.12, respectively. After reading each text, students were asked to write down responses to questions in which they 1) identified the type of text structure in the given text, 2) drew a graphic organizer of the texts, and 3) wrote a text summary. The readability level was calculated using Ging's (1994) Chinese readability scale and the formula can be found in Appendix F.

On the following day, students were required to finish the other set of tests on generic text reading comprehension. The comprehension questions that they were required to respond to were the same as those used in the reading test on science texts. The four generic texts used to assess reading comprehension, which were the same as those used in the CRCT mentioned below, had readability levels of 8.85, 9.12, 7.57, and 8.01, respectively.

Standardized reading tests. In addition to the author-developed tests discussed above, two standardized reading tests were used to assess far transfer of reading ability. The first is named the CRCT (Chinese Reading Comprehension Test), which is adopted from high school entrance exams in China. The second is named the PISA test, which is adopted from the Chinese version of the PISA (Program of International Students Assessment) reading test. Both tests include multiple-choice and short-answer questions. The difference between them is that the CRCT requires students to read four passages and to complete the questions after each, while the PISA reading tests requires students to read six passages and to respond to the comprehension questions for each text.

Chinese Reading Comprehension Test (CRCT). The CRCT was adopted from the High

School Entrance Exam of Shanghai, China (Zhang & Zhu, 2011) and is a subtest of the state

reading comprehension test called the High School Entrance Exam of Chinese Language and

Arts (HSEE-CLA), a province- or city-administrated high-school entrance exam for all middle

school students. The HSEE-CLA test usually contains three subscales. The first includes

multiple-choice questions concerning Chinese language and literature. The second subscale

involves reading two texts, one narrative and one expository or argumentative text, each of

which is followed by five to seven questions including multiple-choice, fill-in-the- blank, and

short-answer. The third subscale is the writing assessment.

Since the HSEE-CLA reading test is the only large-scale reading test administered in

China to assess students' reading performance at the middle school level, the CRCT adopted

from the HSEE-CLA is expected to be a valid measure of students' general reading performance

for this study. Moreover, only those part of HSEE-CLA reading tests that focus on

comprehension of expository texts was included in the CRCT. For the posttest in this study, four

reading tasks were selected from previous HSEE-CLA tests (2007-2010), one from each year's

test.

PISA reading test. The first part of the standardized reading test used in this study is

from subtests of the PISA in Mandarin (Lu, 2013; OECD, 2018). The PISA is an international

assessment that measures the performance of 15-year-olds across reading, math and science. The

test is administered every three years in the 34 member countries of the Organization of

Economic Cooperation and Development (OECD, 2018). In 2009, the PISA was implemented in

China for the first time but only the reading part was administrated. Due to the lack of nation-

wide test dedicated to assessing the reading ability of middle-school students in Mainland China

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and the global acceptance of the PISA test, in accordance with previous studies, the main study adopted the PISA test as a form of standardized reading test in both the pretest and posttest (Fleischman, Hopstock, Pelczar, & Shelley, 2010).

The PISA reading subtest used in this study was adopted from PISA 2009 and PISA 2018, which have been published online (Lu, 2013; OECD, 2018). Ten sample reading tasks from the 2009 test and three reading tasks from the 2018 test were retrieved from the official PISA website. Those reading tasks vary in the form of comprehension, including text paragraphs, figures, and maps. After reviewing both the English version and Chinese versions of all of the tasks, 10 tasks focusing on comprehending text paragraphs were included in the test used for the main study.

The final reading test consists of 10 tasks covering three text genres, namely expository, narrative, and argumentative. The test items include multiple-choice questions and short-answer questions. The number of questions for each paragraph, ranges from three to four, and the total number of questions for the test is 40. The test was equally split into form A and form B, with each containing five paragraphs and 20 questions. Form A was administered in the pretest, while form B was administered in the posttest.

PISA science test. Previous studies have indicated that comprehension of science depends on reading skills and background science knowledge (Fang, 2010). Therefore, in this study a science subtest adopted from PISA 2006 (OECD, 2018) was also administered and used as a covariate to predict students' performance in terms of reading and learning of science texts. Ten scientific inquiries covering biology, geology, chemistry, and other science topics were randomly selected from the pool of 26 inquiries in PISA 2006 (OECD, 2018). Each scientific inquiry requires students to read background material and then provide responses to three to four

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questions. The total number of questions is 36. The test was also divided into forms A and B, which were administrated in the pretest and the posttest, respectively.

Procedure

 Teacher recruitment. The school was recruited through the author's personal connections, and the study was approved by the school administration. The school administration office sent a recruitment letter regarding this study to all teachers. Two sixth-grade Chinese language art teachers from the school responded and volunteered to participate in the study. Both teachers are female and hold master's degrees in education. They have been teaching the Chinese language at the school involved in this study for more than eight years, but have little experience in science instruction.

 Student recruitment. The students who participated in this study were from two classes whose lead teachers were those volunteered for this study. In accordance with the Institutional Review Board requirements at Teachers College at Columbia University, student assent forms and parent consent forms were obtained from students with the help of their teachers. The study was conducted in May and June of 2018, near the end of the school year.

 Teacher training and material delivery. Prior to the beginning of this study, the author held a half-day on-site meeting with the teachers who volunteered to deliver the instruction in both conditions. During the training meeting, the purpose of the study was discussed, and each lesson of the program was reviewed. Detailed written instructions, including how to use the provided reading and writing materials in the class, were provided to the teachers and reviewed during the meeting. Although the teachers were permitted to tailor the instruction according to their own teaching styles and professional judgment, they were still required to teach all content and concepts presented in the lessons.

Intervention. Immediately after completing the pretest, all students attended a 15-lesson reading program in their regular Chinese language art class within 15 consecutive days, roughly one lesson per day. Each lesson lasted approximately 30 minutes. Teachers were asked to follow the point-by-point instructions provided for each activity when delivering each lesson. In the meantime, students were asked to follow the instructions in their student handbook regarding reading texts, participating in group discussions, and conducting individual practice.

Assessments. The assessments for this study include the pretest and the posttest.

Pretest. The pretest was administered to students with the help of teachers, prior to the beginning of the program. The pretest included two sections, the PISA reading test and the PISA science test, which were conducted over two consecutive days. Students were assigned 45 minutes to complete each part.

Posttest. The posttest was administered to students by their Chinese language art teachers immediately after the completion of the program. The four parts of the posttest--the PISA reading test, the PISA science test, reading comprehension test of science texts, and reading comprehension test of generic test together with the CRCT--were administered over four consecutive days. Table 8 presents a detailed timeline of the study.

Table 8

Timeline of the Study

Activity	Frequency	Duration	Total time period
Paper-Pencil Pretest	2	45 min	2 days
Reading Intervention	15	30 min	15 days
Paper-Pencil Posttest: PISA Reading	1	45 min	1 days
Paper-Pencil Posttest: PISA Science	1	45 min	1 day
Paper-Pencil Posttest: Reading Comprehension Test of Science Texts	1	45 min	1 day
Paper-Pencil Posttest: Reading Comprehension Test of Generic Texts and Chinese Reading Comprehension Test (CRCT)	1	45 min	1 day

Treatment fidelity. The treatment fidelity of this study was assessed using the classroom observation, the protocols for which were developed by the author based on the work of Williams (2016) and Kao (2015). Since the treatment of fidelity in this study was designed to be assessed using the classroom observations of a third party, the observation protocol was developed and served as guideline for the research assistants (RAs) who monitored the intervention.

The observation protocol of the 15 lessons for the CSTS and the CONT programs consists of checklists for every activity designed to be conducted in each lesson. Space was provided in the form to note the time spent on each activity and whether the activity was

completed. There was also space for taking notes about students' engagement and whether each activity and the content included in the activity were appropriate for the age group.

Two RAs from the research department of the participating school were recruited to observe the classes. One of the RAs is a former college language teacher with seven years of teaching experience who is in charge of developing reading programs for the school's students. The other RA is a recent graduate with a master's degree in science education who is currently working as the researcher of the school's science curriculum. The author trained both RAs through a phone meeting and explained the purpose of the classroom observation and how the classroom observation protocol should be used during the observations.

During the study, 60% of the lessons were randomly selected and observed by two RAs. During the observations, the completion of each activity in both the CSTS program and CONT program was rated by RAs by checking the "full completion", "partial completion" or "not covered" boxes provided in the observation protocols. An analysis of the observation reports by the author indicated 88% full completion and 12% partial completion. Note that additional activities conducted by the instructors but were not included in the program were not recorded during the observations. For example, some minimal instruction in text structure was taught to students in the control group as part of the regular instruction, but was not recorded for assessing the treatment fidelity.

Scoring

The scoring protocols include scoring manuals for the standardized tests and scoring rubrics for both the text structure knowledge and reading comprehension tests. The rubrics were developed by the author and reviewed by the Chinese teachers involved in the study. Examples of each rubric are presented in Appendix G. All scoring was done manually by two raters.

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Standardized test scoring. The CRCT score was based on the accuracy with which the students identified the information from the paragraphs, in accordance with the instructions stipulated in the test manual. When scoring the fill-in-the-blank and multiple-choice items, a correct response received one point, while an incorrect response received no points. When scoring the short-answer questions, a fully correct response received one point, while a partially correct response and an incorrect response received a half-point and no points, respectively. The total score for the CRCT is 39 points.

The PISA test scoring is based on answer keys, which are provided in the scoring manual that comes with each test. A correct response receives one point, and an incorrect or absent response receives no point. The total score for each of two forms on the reading test is 20 points, and the total score for each form on the science test is 18 points.

Text structure knowledge scoring. The scoring of this part of the test is based on the correct responses to each question related to the text structure knowledge. Specifically, a correct response received one point, and incorrect responses or no response receives no points. The total score for the knowledge of the structure of both science and generic texts is 8 points.

Science text comprehension scoring. This scoring of this part of the test is used to measure the recall of idea units in the top-level structure of each science text. According to Meyer and her colleagues (2017), those important ideas can be seen as information that is organized with text stop-level structures and focuses on macro-propositions, rather than micro-propositions within a sentence or between adjacent sentences. Using this method, the first text, "Diabetes", is identified with 17 points of GO/important ideas and 12 points of text summary. The second text, *Pain*, includes 11 points of GO/important ideas and 9 points of text summary. The third text, "The Effects of Light on the Growth of Plants", includes 20 points of

GO/important ideas and 18 points of text summary. The fourth text, "Colony on the Mars", includes 31 points of GO/important ideas and 20 points of text summary. Therefore, for science text comprehension, the total scores for GO/important ideas and text summary are 79 and 59 points, respectively.

Generic text comprehension scoring. Similar to the comprehension of science texts, the scoring of this part of the test is also used to measure the recall of idea units in the top-level structure of each text. The first text, "Chinese Red", includes 14 points of GO/important ideas and 11 points of text summary. The second text, "Chinese Porcelain", includes 18 points of GO/important ideas and 13 points of text summary. The third text, "The Deep Ocean Water", includes 19 points of GO/important ideas and 17 points of text summary. The fourth text, "The Landscape of Urban Cities", includes 29 points of GO/important ideas and 12 points of text summary. Therefore, for generic text comprehension, the total points for the GO/important ideas and the text summary are 80 and 53 points, respectively.

All the important ideas in all texts used in this study were stated explicitly. The scoring protocol covering the unit ideas in the texts' top-level structure was reviewed and confirmed by two middle school Chinese language arts teachers who taught the program in the study.

Scoring training. To ensure the validity of the scoring, two raters were involved in the scoring. The author served as the first rater. The second rater was a science teacher with five years of science teaching experience who were recruited and trained by the author. A three-hour face-to-face meeting was conducted for the scoring training. During the training, the author presented the scoring protocols described above to the second rater and demonstrated how to enter data in each column on the scoring sheets. In addition, the author and the second rater reviewed the scoring of several examples to ensure that the second rater fully understood the

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scoring system. After the completion of the scoring process, the author reviewed all scoring sheets to ensure accuracy.

Inter-rater reliability. Of all the responses collected, 20% of all the responses collected for each variable was randomly selected to measure the inter-scorer agreement. Both the first and second raters scored the selected tests independently and then compared their results. Disagreements were resolved through discussions, followed by a new round of independent scoring and comparison. An inter-rater reliability agreement of 95% was achieved through multiple rounds. Thereafter, two raters divided the remaining response sheets and scored them independently. The inter-rater reliability scores of five tests can be found at Table 9.

Table 9

Inter-rater Reliability for Each Test

Tests	Inter-rater reliability
PISA Reading Test	98.34%
PISA Science Test	98.02%
Chinese Reading Comprehension Test (CRCT)	96.84%
Test of science texts	95.71%
Test of generic texts	96.82%

Data Analyses

The main purpose of this study is to test the effectiveness of CSTS instruction, which is the only independent variable. There are five dependent variables, including text structure knowledge of science texts, text structure knowledge of generic texts, reading comprehension of

science texts, reading comprehension of generic texts, and performance on standardized reading tests. The PISA reading and science pretest scores were used as two covariates.

MANCOVAs (multivariate analysis of covariance) were conducted to analyze the overall effects of the instruction using SPSS 24. The first MANCOVA was conducted using all outcomes measures by controlling the pretests in both PISA reading and PISA science. Then, a second MANCOVA was also conducted by removing measures with zero scores in the control group. Based on the findings from the MANCOVA, follow-up one-sample T-test or one-way ANCOVAs (analyses of covariance) were conducted for each dependent variable using the PISA reading pretest and/or the PISA science pretest as covariates. Specifically, one-sample t-tests on the text structure knowledge on both science texts and generic texts were conducted while one-way ANCOVAs on reading comprehension of science texts were conducted using both PISA reading and PISA science as covariates. One-way ANCOVAs on reading comprehension of generic texts and standardized reading test were conducted using PISA reading as the only covariate.

CHAPTER IV

RESULTS

Descriptive Statistics

The means and standard deviations for each of the individual measures of each condition are presented in Table 10. The treatment group consisted of students receiving Comprehension Science Text with Structure (CSTS) instruction, while the control group was made up of students receiving the Content-only (CONT) program. All original scores were converted into percentage scores. Two subtleties regarding the data are worth noting:

First, the results indicate that there is a significant difference between the control ($M = 80.69$, $SD = 8.99$) and the treatment ($M = 72.73$, $SD = 13.01$) groups for the PISA reading pretest with $t(1,86) = 3.34$, $p < 0.05$, despite the fact that the students were randomly assigned to the two groups. It is highly unusual to have such a difference with random assignment. After considering all possibilities, no reasonable explanation could be found for the cause of this unusual situation. However, this abnormality would not affect the results of this study, as the PISA pretest score is used as covariate in analyzing the outcome measures.

Second, the control group shows zero or near-zero values for the measures of text structure knowledge and GO/generation. Those values are the results of the across-the-board zero scores received by students in the control group for related questions. This is expected as Chinese students' exposure to the rhetoric text structure of expository texts is limited in regular Chinese language art classes. Thus, students in the control group were neither able to correctly identify the text structure type for a given text nor able to draw a graphic organizer to represent the relationship among textual information.

Table 10

Means and Standard Deviations of Measures, by Treatment (N = 88)

	Treatment, *n* = 43	Control, *n* = 45
	M (SD)	*M* (*SD*)
Pretest		
PISA Science Pretest	58.07 (15.59)	56.77 (14.95)
PISA Reading Pretest	72.73 (13.01)	80.69 (8.99)
Posttests with Science Text		
Text Structure Knowledge, Science	52.91 (38.66)	0 (0)
GOᵃ/generation, Science	18.60 (25.64)	0 (0)
GO/important ideas, Science	31.53 (16.03)	23.87 (11.77)
Text Summary, Science	16.63 (14.54)	5.28 (7.15)
Posttests with Generic Text		
Text Structure Knowledge, Generic	65.12 (37.85)	0 (0)
GO/generation, Generic	56.98 (36.32)	0.56 (3.73)
GO/important ideas, Generic	37.97 (15.62)	27.98 (13.00)
Text Summary, Generic	27.40 (19.13)	9.23 (9.28)
Standardized Posttests		
Chinese Reading Comprehension Test (CRCT)	69.14 (14.02)	71.74 (7.81)
PISA Science, Posttest	63.06 (12.84)	62.95 (11.80)
PISA Reading, Posttest	74.40 (9.38)	75.35 (6.40)

[a]GO: Graphic Organizer.

The correlation between measures is presented in Table 11. The results suggest that the PISA science pretest is significantly correlated with the GO/important ideas of science texts [$r(85) = 0.22, p < 0.05$], the GO/important ideas of generic texts [$r(85) = 0.22, p < 0.05$], the CRCT [$r(85) = 0.45, p < 0.01$], and the PISA science posttest [$r(85) = 0.45, p < 0.01$]. The results also indicate that the PISA reading pretest is significantly correlated with the text structure knowledge of science texts [$r(87) = 0.24, p < 0.01$] and generic texts [$r(87) = 0.27, p < 0.01$], as well as the GO/generation of generic texts [$r(87) = 0.23, p < 0.05$].

The measures developed by the author to assess student knowledge of text structures and comprehension of texts are also positively correlated. The text structure knowledge of science texts is significantly correlated with the text structure knowledge of generic texts [$r(88) = 0.79, p < 0.01$], the GO/generation of science texts [$r(88) = 0.53, p < 0.01$] and generic texts [$r(88) = 0.72, p < 0.01$], the GO/important ideas of science texts [$r(88) = 0.43, p < 0.01$] and generic texts [$r(88) = 0.45, p < 0.01$], and the text summary of science texts [$r(88) = 0.70, p < 0.01$] and generic texts [$r(88) = 0.69, p < 0.01$]. The GO/generation of science texts is significantly correlated with the GO/generation of generic text [$r(88) = 0.43, p < 0.01$], the GO/important ideas of science texts [$r(88) = 0.44, p < 0.01$], the text summary of science texts [$r(88) = 0.44, p < 0.01$] and generic texts [$r(88) = 0.27, p < 0.05$], and the text structure knowledge of generic texts [$r(88) = 0.39, p < 0.01$]. The GO/important ideas of science texts is significantly correlated with the GO/important ideas of generic texts [$r(88) = 0.50, p < 0.01$], the text summary of both science texts [$r(88) = 0.61, p < 0.01$] and generic texts [$r(88) = 0.36, p < 0.01$], the knowledge of text structure of generic texts [$r(88) = 0.24, p < 0.05$] and the GO/generation of generic texts [$r(88) = 0.36, p < 0.01$]. The text summary of science texts is significantly correlated with the knowledge of text structure of generic texts [$r(88) = 0.48, p < 0.01$], the GO/generation of

generic texts [$r(88) = 0.54$, $p < 0.01$], the GO/important ideas of generic texts [$r(88) = 0.39$, $p < 0.01$], and the text summary of generic texts [$r(88) = 0.66$, $p < 0.01$]. The text structure knowledge of generic texts is significantly correlated with the GO/generation of generic texts [$r(88) = 0.72$, $p < 0.01$], the GO/important ideas of generic texts [$r(88) = 0.37$, $p < 0.01$] and the text summary of generic texts [$r(88) = 0.59$, $p < 0.01$]. The GO/generation of generic texts is significantly correlated with the GO/important ideas of generic texts [$r(88) = 0.66$, $p < 0.01$] and the text summary of generic texts [$r(88) = 0.40$, $p < 0.01$]. The GO/important ideas of generic texts is significantly correlated with the text summary of generic texts [$r(88) = 0.30$, $p < 0.01$].

The measures adopted from the CRCT, the PISA reading posttest, and the PISA science posttest are also significantly correlated with measures developed by the author to assess student text structure and comprehension knowledge. The CRCT is significantly correlated with the GO/important ideas of generic texts [$r(88) = 0.21$, $p < 0.05$], the GO/generation of generic texts [$r(88) = 0.40$, $p < 0.01$] and the text summary of generic texts [$r(88) = 0.30$, $p < 0.01$]. The CRCT is also significantly correlated with the PISA science posttest [$r(88) = 0.33$, $p < 0.01$]. The PISA science posttest is significantly correlated with the GO/important ideas of science texts [$r(88) = 0.33$, $p < 0.01$] and generic texts [$r(88) = 0.33$, $p < 0.01$]. Lastly, the PISA reading posttest is significantly correlated with PISA science posttest [$r(88) = 0.48$, $p < 0.01$].

Table 11

Correlations Among Measures (N=88)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1.PISA Science, Pretest	1												
2.PISA Reading Pretest	.06	1											
3.Text Structure Knowledge, Science	.18	.24*	1										
4. Graphic Organizer (GO) Generation, Science	.17	.05	.53**	1									
5.GO/important ideas, Science	.22*	.13	.43**	.44**	1								
6.Text Summary, Science	.15	.08	.70**	.44**	.61**	1							
7.Text Structure Knowledge, Generic	.17	.22*	.79**	.39**	.24*	.48**	1						
8. Graphic Organizer (GO) Generation, Generic	.12	.23*	.72**	.45**	.36**	.54**	.724**	1					
9.GO/important ideas, Generic	.23*	.14	.44**	0.16	.50**	.39**	.378**	.61**	1				
10.Text Summary, Generic	.20	.20	.69**	.27*	.36**	.66**	.589**	.74**	.66**	1			
11.Chinese Reading Comprehension Test (CRCT)	.33**	.02	.12	.09	.19	.09	0.12	.21*	.40**	.30**	1		
12.PISA Science, Posttest	.45**	.18	.19	.19	.33**	.12	0.16	.10	.22*	.09	.33**	1	
13.PISA Reading, Posttest	.17	.02	.11	.12	.19	.10	0.09	.15	.13	.13	.19	.48**	1

$* p < .05$, $** p <. 01$

Multivariate Analysis

A one-way MANCOVA was conducted on all dependent measures: text structure knowledge of science texts, graphic organizer generation of science texts, GO/important ideas of science texts, text summary of science texts, text structure knowledge of generic texts, graphic organizer generation of generic texts, GO/important ideas of generic texts, text summary of generic texts, the CRCT, the PISA reading posttest, and the PISA science posttest. The independent variable is the instruction condition (treatment vs. control), and the PISA Reading pretest and PISA science pretest were covariates. The MANCOVA results are presented in Table 12. There is a statistically significant main effect of instruction (treatment vs. control), $F(11, 67)$ = 23.4, $p < 0.01$, $\eta^2 = 0.79$.

Table 12

Multivariate Analysis of Covariance for All Outcome Measures

Source	Wilks' Lambda	F (11, 67)	p	η^2
PISA Science Pretest	0.74	2.19*	0.02	0.26
PISA Reading Pretest	0.82	1.36	0.20	0.18
Condition (CSTS[a] vs. CONT[b])	0.21	23.5**	0.01	0.79

* $p < .05$, ** $p < .01$

[a]CSTS: Comprehending Science Texts with Structure. [b]CONT: Content-only

Given the fact that the control group showed zero on text structure knowledge and lack of variance on those measures, a second MANCOVA was conducted with the measures only on comprehension and standardized reading comprehension tests. The measures include GO/important ideas of science texts, text summary of science texts, GO/important of generic texts, text summary of generic texts, Chinese Reading Comprehension Test, and PISA reading

posttest, with PISA reading pretest and PISA science pretest as covariates. The results are presented in Table 13. There is a statistically significant main effect of instruction (treatment vs. control), $F(7, 71) = 6.54$, $p < 0.01$, $\eta^2 = 0.25$.

Table 13

Multivariate Analysis of Covariance for Measures on Comprehension

Source	Wilks' Lambda	$F(7, 71)$	p	η^2
PISA Science Pretest	0.93	1.53	0.20	0.07
PISA Reading Pretest	0.91	1.82	0.13	0.09
Condition (CSTS[a] vs. CONT[b])	0.75	6.45**	0.01	0.25

* p < .05, ** p <. 01

[a]CSTS: Comprehending Science Texts with Structure. [b]CONT: Content-only

To answer the specific areas of the research questions of this study, results of a further analysis of each measure using ANCOVA are reported below and all original ANCOVA outputs from SPSS are display in Appendix H.

Outcomes in Knowledge of the Structure of Science Texts

The first area of the first research question investigates whether Mandarin-speaking students who participate in a text structure intervention using science texts demonstrate better knowledge of the structure of science texts compared to students receiving the CONT program. Two sub-measures are used to assess student knowledge of text structure: The first measure is text structure knowledge, which assesses a student's ability to identify the primary text structure of each of four science stimulus texts. The second is the graphic organizer generation, which assesses a student's ability to generate an appropriate GO based on the text structure of each of four stimulus science texts.

One sample t-test was conducted to determine whether there is a statistically significant difference between the treatment group, which received the CSTS instruction and the Chinese middle school students in general. The results are presented in Table 14.

The results reveal a statistically significant main effect for text structure knowledge of science texts, with $t(42) = 8.96$, $p < 0.01$, and CI [41.01, 64.80]. The treatment group ($M = 52.91$, $SD = 38.66$) illustrated the acquisition of text structure knowledge of science texts is significant.

The results also reveal a statistically significant main effect for the GO/generation of science texts, with $t(42) = 4.76$, $p < 0.01$. In generating appropriate graphic organizers for science texts, the performance of the treatment group (M = 18.60, SD = 25.66) is also statistically significant comparing to the students in population. The 95% confidence interval of difference of this measure is [10.71, 26.50]. Those results also suggest that the text structure intervention is effective in helping student learn text structure knowledge for science texts.

Table 14

One Sample t-test for the Knowledge of Text Structure of Science Text

	Treatment (*n*=43)			95% CI	
Measures	*M*	*SD*	*t(42)*	Lower	Upper
Text Structure Knowledge, Science	52.91	38.66	8.96**	41.01	64.80
GO[a]/generation, Science	18.60	25.64	4.76**	10.71	26.50

** *p* <. 01

[a]GO: Graphic Organizer.

Outcomes in Knowledge of the Structure of Generic Texts

The second area of the first research question asks tests the transfer of text structure knowledge from science texts to generic texts and includes two sub-measures. The first sub-measure is text structure knowledge, which assesses a student's ability to identify the primary text structure of each of four generic expository texts. The second is GO/generation, which assesses a student's ability to generate an appropriate GO based on the text structure of each of four stimulus generic expository texts.

One sample T-test was conducted to discern whether the statistical significance of the gain for students in the treatment group in both measures exists. These results, which are presented in Table 15, reveal a significant main effect for the text structure knowledge of generic texts, with $t(42) = 11.28$, $p < 0.01$. The treatment group ($M = 65.12$, $SD = 37.85$) demonstrated a significant improvement of text structure knowledge of generic texts, with the 95% confidence interval of [53.47, 76.77]. The results also reveal a significant effect for the GO/generation of generic texts, with $t(42) = 10.28$, $p < 0.01$. The treatment group ($M = 56.98$, $SD = 36.32$)

demonstrated the acquisition of generating the appropriate graphic organizers of generic texts, with the 95% confidence interval of [45.80, 61.85]. As a result of these findings, the text structure intervention is confirmed as being effective in improving student knowledge of the text structure of generic texts.

Table 15

One Sample t-test for the Knowledge of Text Structure of Generic Text

	Treatment (*n*=43)			95% CI	
Measures	*M*	*SD*	*t* (42)	Lower	Upper
Text structure Knowledge, Generic	65.12	37.85	11.28**	53.47	76.77
GO[a]/generation, Generic	56.98	36.32	10.28**	45.80	68.15

** *p* <. 01

[a]GO: Graphic Organizer.

Outcomes in Comprehension of Science Texts

The first area of the second research question examines whether Mandarin-speaking students who undergo a text structure intervention using science texts demonstrate better comprehension of science texts compared to students receiving the CONT curriculum. The two measures used to assess reading comprehension are 1) text summary, which includes important ideas in a summary of the science text, and 2) GO/important ideas, which contains a number of important ideas from the source science text included in a GO.

A one-way ANCOVA was conducted to identify whether statistically significant differences existed between the treatment group and the control group on both measures while controlling for the PISA reading pretest and PISA science pretest. The results of this analysis are presented in Table 16; they indicate a significant main effect for the GO/important ideas of

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science texts, with $F(1, 82) = 7.58$, $p < 0.01$, $\eta 2 = 0.09$. Students who received the CSTS

program ($M = 30.51$, $SD = 16.13$) were able to include more important ideas in their graphic

organizers compared to students who underwent the CONT program ($M = 23.96$, $SD = 11.89$).

The results also reveal a significant main effect for the text summary of science texts, with $F(1,$

$82) = 16.12$, $p < 0.01$, $\eta 2 = 0.17$. The CSTS students ($M = 14.97$, $SD = 13.63$) were able to

include more important ideas in their summaries of science texts than the CONT students are

able to write ($M = 5.4$, $SD = 7.19$). Furthermore, these results suggest that the text structure

intervention is effective in improving the students' ability to comprehend science texts.

Table 16

Univariate Analysis of Covariance for Comprehension of Science Text

	Treatment (*n*=40)		Control (*n*=44)			
Measures	*M*	*SD*	*M*	*SD*	*F* (1, 82)	η2
GOᵃ Important Ideas, Science	30.51	16.13	23.96	11.89	7.58**	0.09
Text Summary, Science	14.97	13.63	5.40	7.19	16.12**	0.17

* $p < .05$, ** $p < .01$

ᵃGO: Graphic Organizer

Outcomes in Comprehension of Generic Texts

The second area of the second research question also tests the transfer of comprehension

skills from science to generic texts. Two measures, the text summary of generic texts and the

GO/important ideas of generic texts, were used to address this question. A one-way ANCOVA

was conducted to determine if a statistically significant difference exists between the treatment

group and the control group on both measures when controlling for the PISA reading pretest. The

results are presented in Table 17.

The analysis results illustrate a significant main effect for the GO/important ideas of generic texts, with $F(1, 85) = 8.61$, $p < 0.01$, $\eta2 = 0.09$. The CSTS students ($M = 37.97$, $SD = 15.81$) were able to include more important ideas in their graphic organizers than those who underwent the CONT program ($M = 27.98$, $SD = 13.00$). The results also reveal a significant main effect for the text summary of generic texts, with $F(1, 85) = 26.17$, $p < 0.01$, $\eta2 = 0.24$. The CSTS students ($M = 27.17$, $SD = 19.3$) were able to include more important ideas in their summary of generic texts compared to the CONT students ($M = 9.23$, $SD = 9.28$). Therefore, these results suggest that the text structure intervention is effective in improving students' ability to comprehend generic texts.

Table 17

Univariate Analysis of Covariance for Comprehension of Generic Text

	Treatment (n=42)		Control (n=45)			
Measures	*M*	*SD*	*M*	*SD*	*F* (1, 85)	η2
GO[a] Important Ideas, Generic	37.97	15.81	27.98	13.00	8.61**	0.09
Text Summary, Generic	27.17	19.30	9.23	9.28	26.17**	0.24

*p < .05, ** p <. 01

[a]GO: Graphic Organizer

Outcomes in Standardized Reading Tests

The third area of the second research question assesses the transfer of reading comprehension on standardized reading tests. The CRCT and PISA reading posttest are the measures used to answer this area of the research question. A one-way ANCOVA was conducted to determine whether a statistically significant difference exists between the treatment group and the control group on both measures, controlling for the PISA reading pretest. The analysis results

are presented in Table 18. However, the results indicate no significant main effect for the CRCT, with $F(1, 85) = 1.33$, $p > 0.05$, and no significant main effect for PISA reading posttest, with $F(1, 85) = 6.4$, $p > 0.05$.

Table 18

Univariate Analysis of Covariance for Standard Test Score

Measures	Treatment ($n = 42$)		Control ($n = 45$)			
	M	*SD*	*M*	*SD*	*F* (3, 80)	η2
Chinese Reading Comprehension Test (CRCT)	68.95	14.13	71.74	7.81	1.33	0.02
PISA Reading Posttest	74.33	9.47	75.35	6.40	0.85	0.00

* $p < .05$, ** $p < .01$

CHAPTER V

DISCUSSION

Summary of Findings

As the main purpose of this study, the effects of the Comprehending Science Texts with Structure (CSTS) program developed by the author in terms of improving students' reading comprehension of science texts were carefully examined using a rigorous experimental design. The CSTS used in this study is a 15-lesson reading program specifically designed to teach middle school students how to read and comprehend science text using text structure strategies including generic questions (GQs), graphic organizers (GOs), and summary writing (SW). A total of 88 sixth graders participated in this study and were randomly assigned into either the intervention or the control groups. After the completion of the program, the outcomes were quantified by comparing students' performance in the following three categories: text structure knowledge, comprehension and standardized reading comprehension tests. The results of the study indicate that the CSTS has promising effects in helping students improve their performance in terms of their knowledge of text structure and comprehension of science texts, but not on the standardized reading tests. Those findings are similar to other text structure reading interventions that were conducted among different groups (Cantrell et al., 2010; Salvin et al., 2008; Wijekumar et al., 2014; Wijekumar, Meyer & Lei, 2017; Williams et al., 2016). Moreover, since a literature search found no studies with Mandarin-speaking students regarding science text structure, this study makes a unique contribution to the understanding of reading comprehension in science, particularly for Mandarin speakers.

In the following paragraphs, further details regarding each findings are described separately and related to each area of the research questions presented in the introduction.

Outcomes in knowledge of the structure of science texts. The first area of the first research question asked whether students who received the text structure instruction using science texts demonstrate better knowledge of the structure of science texts than the students in population. Two measures, text structure knowledge and the generation of Graphic Organizers (GO/generation) of science texts, were used to answer this question. As shown in the results, the students in the treatment condition indeed demonstrated the significant acquisition in those two measures. Those results indicate that students in the treatment condition did acquire the necessary knowledge of text structure, as they demonstrated the ability to identify the text structure of science stimulus texts and to generate an appropriate graphic organizer of a science text. Thus, the intervention was successful in teaching techniques that researchers deemed important to be learned.

Outcomes in knowledge of the structure of generic texts. The second area of the first research question asked whether the students who received the text structure instruction using science texts would gain knowledge of the structure of generic texts. This area of the research question is related to the near-transfer effects from science texts to generic texts. Students in the treatment condition were expected to be able to transfer their knowledge of text structure from science texts to generic texts. The outcome was tested using two measures of students' ability: 1) being able to identify the text structures of generic texts, and 2) being able to generate an appropriate graphic organizer of a generic text. As shown in the results, the students in the treatment condition demonstrated significant acquisition in both of those two measures: text structure knowledge of generic texts and generation of GO of generic texts. Thus, the intervention was successful in helping students to transfer the techniques that they have learned using science texts to other types of texts.

Outcomes in comprehension of science texts. The first area of the second research question asked whether the students who received the text structure instruction using science texts would demonstrate better comprehension of science texts than their counterparts in the CONT program. The comprehension of science texts was assessed using two measures: 1) the ability to include the important ideas of a science text in a GO and 2) the ability to write a summary of the important ideas in a science text. The students in the treatment condition significantly outperformed the students in the comparison group on both measures. Thus, the CSTS intervention did help participating students improve their comprehension of science texts.

Outcomes in comprehension of generic texts. The second area of the second research question asked whether students who received the text structure instruction using science texts would demonstrate better comprehension of generic texts than their counterparts in the CONT program. This question also investigated the near-transfer effects from science texts to generic texts. Similar to the third area of the research question, students in the treatment condition were expected to transfer their comprehension on science texts to generic texts, which was tested using two measures: 1) the ability to include the important ideas in a generic text in a GO and 2) the ability to write a summary of the important ideas in a generic text. As shown in the results, the students in the treatment condition significantly outperformed the students in the control group on both measures. Therefore, the CSTS intervention did help the participating students transfer their ability of science text comprehension to the generic texts.

Outcomes in scores on standardized reading tests. The third area of the second research question asked whether students who received the text structure instruction using science texts would demonstrate better scores on standardized reading tests than their counterparts in the CONT program. In contrast with the answers to the previous areas of the

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research questions, the answer to this question is no. There were no significant differences for either the CRCT or the PISA reading posttest. This result means that far-transfer effect of the CSCT from science text to general reading comprehension was not found in this study. The reason of this finding could be the fact that the reading skills students acquired from the CSTS program were not tested in the standardized tests. Specifically, the reading skills that students learned in the program include identifying the text structures, generating graphic organizers using text structure and write a summary using their text structure knowledge, are not necessarily needed in completing those two standardized tests used in the study. However, it remains unclear if other aspects of the far-transfer of the CSCT, for example, that from science text comprehension to science concepts learning exist. It is worth to be investigated in future studies.

Summary. With the results of the measures specifically designed to answer the five areas of the research questions and test the five hypotheses, this study demonstrated that CSTS produced promising outcomes in helping students to improve their performance on the knowledge of text structure and comprehension of science texts. Therefore, this study confirmed the effectiveness of a content-area reading intervention focusing on text structure.

This study has clearly demonstrated that a reading intervention focusing on text structure can indeed effectively help Mandarin-speaking students to strength their reading comprehensions of both science and generic texts. More importantly, the promising results of this study could be used to promote the development of further experiment-based reading intervention studies in Mandarin settings.

In addition, this study has also demonstrated that, with the help of a reading intervention focusing on text structure, students can demonstrate superior performance in acquiring the knowledge from the science texts. With the increasing need to learn scientific concepts in the

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modern society, how students can be assisted to better comprehending science texts is of great importance. This study contributes to the understanding of content-area comprehension in science and can contribute to the development of more effective instruction that incorporates basic academic skills including reading and writing in science learning.

Implications

Previous studies have indicated that middle school students lack reading instruction focused on text structure in certain content area (Wijekumar, Meyer & Lei, 2017). The results of the current study suggest that middle school students can benefit from the direct instruction concerning text structure using science texts. Theoretically, a text structure strategy can have a powerful effect on constructing students' strategic memories by producing stronger important ideas, organizing those important ideas using centrality of connections, and applying strategies intended to assist in understanding the scientific concepts (Wijekumar, Meyer & Lei, 2017). Therefore, students can benefit from reading instruction that aligns with text structure and treats the text structure as the organizing framework for reading comprehension activities such as summarizing, generating inference, elaborating, and monitoring comprehension. Therefore, both language art teachers and content teachers can potentially implement the text structure in their teaching.

Classroom observations and interviews with the teachers from the study showed that teachers were lacking the knowledge of text structure as well as the implementation of the text structure strategies in their regular teaching. Those findings are similar to the findings from Wijikemar and colleagues (2017), which indicated that few middle school language art teachers knew about the text structure strategies and use text structure as part of their curricula. Therefore, it will be important for language arts teachers to implement the CSTS program as a partial

substitute for a language arts curriculum. By introducing important text structure strategies including asking generic questions, using graphic organizer, and writing a summary, teachers can continue to encourage students to apply these strategies to the reading of all kinds of expository texts. Ultimately, students can transfer those skills to the reading of a wide breadth and scope of texts and thus support their learning of specific subjects in secondary school and beyond.

It is also important for science teachers to implement the CSTS program from the very beginning of science class. By learning how to read authentic scientific texts using the text structure strategies covered in the program, students can apply these skills to learning more complex science concepts later on. Specifically, students will be able to identify the important ideas in a text and rhetorically connect important concepts with each other more effectively; thus, they will eventually enhance their ability to understand new concepts or to correct previous misunderstandings of science concepts (Kendeou & van den Broek, 2007).

Limitations

This study has several limitations. First, as mentioned in the previous chapter, there was a statistically significant difference between the treatment and control groups regarding the scores achieved on the PISA pretest, even though students were randomly assigned to one of these two groups. Although it has been accounted for, as the scores of the PISA pretest were used as covariates in analyzing the data, this difference could still potentially affect the implementation of the CSTS program and the result of the posttest. Reassigning students to achieve no difference in the scores of the pretest may have yielded different results.

There are also limitations in terms of generalizability. This study was conducted in one of the best private schools in the city of Chengdu, which is one of the largest metropolises in China, where students generally perform better than average in their academic aspects. Previous studies

indicated that students at highest levels of reading performance showed the largest gains through reading interventions (Slavin et al., 2008; Wijekumar et al., 2017). Therefore, with high-performance participants in this study, results may thus not be generalized to either public schools in Chengdu nor schools in other parts of China. A larger sample, with more participating schools, including both private and public schools in cities with different populations, may have yielded different results.

Additionally, as noted in the Method chapter, this study took place in the last month of the school year, when teachers and students were generally busy in preparing for the end-of-year exams. Even though all activities were completed, as indicated in the classroom observation reports, it remains unclear whether students were able to fully devote themselves to participating in the CSTS program and how this specific period of the school year may have affected the outcomes. Also, due to the time constraint, the 15-lesson program was conducted within 15 consecutive days, one lesson for each time. This compressed schedule may have affected the outcomes. The results may have been different had the study been conducted at a different time of the school year over a longer period of time.

The switch of teachers for the two groups half-way in the program may also affect the outcomes of the study. Although two teachers involved the study were randomly assigned to one of the program to start with and switched to another program in the middle, there were still unknown factors affect the results of the study. Two teachers are different in their personal background and teaching experience. Moreover, it is also unknown how much the teacher who first taught the intervention program brought the text structure information into the control group. Those factors may all affect the results of the study.

Future Directions

For the future studies, there are many important points that are worth addressing. The first is investigating the application of the intervention on a larger scale. The current study only involved two classrooms in a metropolitan in China; it would be important to test the effectiveness of the instruction in additional classrooms, schools, and cities in China.

Another important direction in future studies would be to investigate the effects of the CSTS program on science content learning. It would be important for students to apply the reading strategies taught in the reading program to comprehending the materials they encounter in their science classes. Different from other content-area texts, such as history and social studies, which consist largely of cause-effect, sequence, and description structures, science texts usually involve cause-effects, comparison, and problems-solutions, as well as the mixture of them. As Meyer (2001) found out, the texts with cause-effects and problems-solutions are the most difficult ones for students to comprehend. Thus, the instruction of text structure covered in the CSTS problem should be helpful in comprehending science texts, especially the texts with most challenging structures. Moreover, text structure strategies taught in the program focus on the top-level structure of the science texts, which is important in learning key concepts in the scientific knowledge system. Therefore, using text structure in learning science may be able to facilitate acquisition scientific knowledge, as well as using that knowledge to solve real scientific problems. Given all those considerations, it will be worthwhile to examine how a science reading instruction involve text structure could help students to achieve better performance in science learning, and in turn, better understand science concepts and solve problems.

Conclusion

This work has demonstrated the feasibility and effectiveness of explicitly teaching reading comprehension instruction to middle school students to help them comprehend science

texts using text structure strategies. The CSTS program trains students how to access and apply rhetoric structure representations to help them advance to a more advanced level of comprehending complex science texts. Additionally, the results had promising implications for reading in many content areas, ranging from science to generic texts. More importantly, this study is unique, as it not only tested the effectiveness of a reading instruction embedded in science content but also did so with students in a country other than the United States and using a language other than English. By extending the text structure instruction to include different languages, grades, and contents, we believe that we can help our students to build strong fundamental skills for learning and developing in their 21st century.

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APPENDIX A

List of Reading Materials in the Instruction

Table A1

List of Paragraphs in Lessons

Title (English)	Title (Chinese)	Structure	Words
1. How Did the Scientists Find the Water in Mars	火星液态水	Sequence	260
2. The Application of Radiation	你被核辐射过吗？	Description	290
3. The Effects of Transgenic Technology on Crops	转基因技术对农作物的影响	Cause-effect	267
4. Vegetable Oil and Animal Fat	植物油和动物油	Comparison	234
5. How to Deal with Hot Autumn	如何应对"秋老虎"	Problem-solution	332
6. Returning to the Moon	人类为什么要重返月球？	Cause-effect	310
7. Earthquake proof in Chinese Traditional Architecture	中国古代建筑的抗震智慧	Description	354
8.Antibacterial Soap vs. Regular Soap	抗菌皂其实不比普通肥皂好	Sequence	347
9. The Similarities between Sharks and Wolfs	鲨鱼和狼，不同物种的相似角色	Comparison	496
10. The World Without Fossil	没有化石燃料的世界	Problem-solution	275
11. If We Can Domesticate Dinosaurs, Which One Would You Choose?	如果我们能驯化恐龙，你想要哪一种？	Description	1079
12. Seasonality in Flu Infections	流感流行的季节性变化	Cause-effect	729
13. Smog	雾霾	C, CE, & P/S	868
14. Red Meat? White Meat? Which One is Healthier?	吃红肉致癌吃白肉健康？	C,DS, CE & P/S	1603

Examples of Generic Questions, Graphic Organizer, and Writing Summary Template

Table B1

Generic Questions Before Reading the Paragraph

Generic Questions:

1. What is the main idea?

2. What are the signaling words?

3. How the author organizes the paragraph?

    a. Cause-effects,

    b. Description,

    c. Sequence

    d. Comparison

    e. Problem-solution

Table B2

Example of Graphic Organizer - Causation

标题 (Title):		
主题句 (Main idea sentence)：		
原因 (cause) 1	⟶	结果(effect)
2	⟶	
3	⟶	

Table B3

Example of Summary Writing Template – Compare-Contrast

标题 **(title)**:

_____

主题句 (Main idea sentence) : _____

_____

相同之处是（The same things are）: _____

_____

不同之处一（One of the different is ）: _____

_____

不同之处二 (the other difference is) : _____

_____

APPENDIX C

An Example of Short Paragraphs

转基因技术对农作物的影响

21 世纪以来，转基因技术有了不少新的突破，这些突破对农作物的改良产生了巨大的影响。转基因技术通过将一个品种的基因加入另一种基因，使该品种的特性发生变化，具备原品种所不具备的因子，增强了作物抗病、抗杂草或抗虫害能力，由此可减少农药和除草剂的用量，降低种植成本。一种作物的基因改良后，因为它们更容易适应环境，能更有效抵御各种灾害的袭击，因此转基因技术可以极大地提高作物单位面积产量。此外，转基因技术在育种过程中的因为采用更为科学和严格的手段对作物的基因进行构建，因此，使用这种技术培育出一种全新的农作物品种，可以使开发农作物的时间大力缩短。

The Effects of Transgenic Technology on Crops

Since the 21st century, transgenic technology has a lot of breakthrough; these breakthroughs have a tremendous impact on the improvement of crop plants. GM technology by adding new genes to one crop can change the characteristics this crop. Therefore, it enhances crop disease resistance, weed or pest resistance capacity, and reduces the cost on pesticide and herbicides. After the genetically modification, because the crops are easier to adapt to the environment and are more effective to resist the attacks of various disasters, thus transgenic technology can greatly increase crop yield per unit area. In addition, in the breeding process, the transgenic technology adopts more scientific and rigorous method, so this technique can shorten greatly in breeding a new kind of crop varieties.

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APPENDIX D

All Researcher-developed Tests

后测一： 说明文阅读

说明：请阅读文章，并回答文章后相应的问题。

阅读一

中国红为什么这么红

①比较一下常见的颜色，便可知中国红是最适合喜庆的颜色。黄色尽管有暖暖的氛围，很明亮，但由于涉及皇权，不宜作喜庆的主色；月华般的白色清淡、纯洁、素雅，犹有百合花般的诗意和温厚的纯粹，却也无法做民间喜庆的主色；紫色低调、冷艳、神秘、优雅、浪漫，犹带紫槿花、勿忘我、紫丁香那般淡淡的自恋，与昂扬热烈的喜庆却风马牛不相及；绿色无疑象征希望和蓬勃的生命，是今天誉满全球的环保色，然而冷静有余，热烈不足，与喜庆氛围又怎能和谐？

②唯有红色是对视觉冲击最强烈的颜色，是最有生气的颜色，其释放的激情与能量，犹如生命在燃烧，具有凌驾任何色彩之上的强烈力量。红色最热烈、最活泼、最鲜亮、最艳丽、最精神，能教人双眼一亮，印象深刻，是无可取代的最适合喜庆的颜色。

③考察光波的长短，也可以明白中国红非常适合喜庆。 光学实验表明：光线的波长越短，散射作用越强，光线的波长越长，散射作用就越弱。在可见光中，红光的波长最长，空气对红光的散射作用最弱。也就是说，红光的穿透力最强，可以传得最远。在喜庆时刻，谁不喜欢红红火火、光鲜醒目呢？谁不喜欢好事传千里呢？

④中国红最适宜喜庆，还有生存择食的因素。人对色彩的感觉是与生俱来的。人的眼睛在观察事物的时候，依次观察的是物体的色彩、形体、线条和点。由此可知，色彩是人类认知外部世界的第一媒介。

⑤香港大学的研究人员观察了生活在乌干达基巴莱国家公园的灵长类动物的饮食习惯，发现猿类和猴子通常利用蓝色和黄色视觉选择所吃的水果；___它们想吃到有营养的鲜嫩树叶，还必须具备分辨红色和绿色的视觉，___鲜嫩的树叶常带有隐隐的红色，能较明显地与其他颜色的树叶相区分。红色是引起兴奋、喜悦的颜色，能明显引起动物视神经细胞的扩展反应。可见，灵长类动物对红色的感觉能力较其他颜色敏感，与长期以来寻找食物所养成的饮食习惯有关。

⑥中国红反映了东方式的神秘。其渊源还可追溯到古代华夏民族对日神的虔诚膜拜。作为中国的吉庆颜色，作为中国人的吉祥文化图腾和精神皈依，中国红表现了中国人的文化心理。

⑦中国红将华夏民族喜庆的色彩习俗打造得美轮美奂。我们每一个人都生活在特定的社会习俗里。习俗的形成无疑必须经过选择，比如中国红被确立为喜庆颜色就是经由中国人聪明的选择，尔后才传染开来，潜移默化，耳濡目染，乃至约定俗成，形成集体心理定势。如果这种习俗看得见、摸得着而且符合生理选择，比如中国红，其固定性还会更强。习俗带有的守恒性和排他性，还会弱化或淹没异类思想，比如，中国人春节皆贴红春联，如果有的人家贴的是绿春联，便会被视作异类。

⑧中国红与青花蓝、琉璃黄、国槐绿、长城灰、水墨黑和玉脂白构筑了一道缤纷的中国传统色彩风景线。

1、第①②段运用了_____的说明方法，其作用是_____。

2、第④段中加点词"依次"能否删去？请说明理由。

_____

3、按照文意，填入第⑤段画线处的词语是（　　　　）

A、只要　因为　　　　B、即使　何况　　　C、既然　何况　　　　D、倘若　因为

4、中国红早已成为华夏民族喜庆的色彩习俗，除春节贴红春联外，请再举出生活中的两个例子：

　（1）　　　　　　　　　　　　　　（2）　　　　　　　　　　　　　　。

5、这篇文章的作者是如何组织文章结构的？请用一句话描述这篇文章的结构。

6. 根据文章提供的信息，请完成文章的思维导图（注：思维导图能够展示文章的重要信息）。

7. 请完成文章概述（注：概述为概括这篇文章的重要信息）。

阅读二

中国瓷器

①中国瓷器是世界公认的伟大发明之一。它之所以名扬天下，主要在于其本身所包含的三项独创技术：胎质、瓷釉、烧结火候。

②中国瓷器的胎质大多具备一定的透明性，所谓有素肌玉骨之像。它的原料多为高岭土，无论东南沿海还是华中各省都有此土，尤其是在江西景德镇高岭村一带，风化了的白云母花岗岩蓄藏丰厚。也就是说，在中华大地取用制瓷原料是得天独厚的。

③瓷釉覆盖在瓷胎上，实际上就形成了一种复合材料。宋代以后，景德镇成为瓷业的主要生产地之一，就是因为这一带开始以"白云石"加入釉中，使瓷番洁白又易于施加彩饰。

④烧结火候，主要是指瓷器烧成的温度。烧制陶器、砖瓦都在1000℃以下，瓷器则不然。据推测，早期瓷器的烧成温度就已经达到1200℃了。日本大阪大学美术史教授木村重信先生曾撰文："尽管要通过1300℃高温锻烧，釉料仍不变色，纹样依然如故，这就是中国瓷器烧制技术上关键的秘密所在。"

⑤中国瓷器享誉世界，也在于它是科学技术与民间工艺美术技法完美结合的产物。传统细瓷早已形成一整套美化装饰的方式方法，不管是刻花、剔花，还是贴花、印花；也不管是堆雕、镂雕，还是镏金、戗金……均极尽缤纷艳丽，堪称_____。早期的纹饰简单、自然，完全由烧瓷艺人自行设计，例如水纹、云纹、花纹和兽纹等。盛唐以来，纹饰大量借鉴金属器皿、各种织物等图案，使瓷器的装饰意味更浓。宋代以后，瓷业工艺技法愈加精细，彩绘画面也刻意追寻名画师的笔意，有的春花烂漫，有的冬雪裹枝，有的高山流水，有的繁星满天……这无不增添了瓷器美的意蕴，

⑥中国瓷器还承载着丰厚的文化积淀。它的彩绘内容有来自民间传说、历史故事，也有"犀牛望月"、"龙凤吉祥"、"_____"等寓意丰富的图案。康熙年间，景德镇窑曾经烧制一组花卉瓷盅，薄胎青花，加彩题句，一盅一花一词。其中梅花盅题为"素艳雪凝树，清香风满枝"；杏花盅题为"青香和宿雨，佳色出晴烟"；桃花盅则题为"风花新社燕，时节归春浓"……瓷精，图美，词句优雅，在有限的空间中令人感受到无限的韵味。

⑦中国瓷器，实在是令人叹为观止。

请回答以下问题：

1、从下列词语中选择恰当的一项，填在第⑤段的横线上。
A 光彩夺目　B 流光溢彩　C 巧夺天工　D 栩栩如生
……均极尽缤纷艳丽，堪称 _____。

2、第⑤段介绍纹饰时采用了_____顺序。纹饰的特征经历了
从_____到 _____从_____到 _____的变化过程。

3、阅读第⑥段，画线句"在有限的空间中令人感受到无限的韵味"，"有限的空间"是
指_____，"无限的韵味"指_____。

4、从全文看，中国瓷器令人叹为观止的原因有：

5、这篇文章的作者是如何组织文章结构的？请用一句话描述这篇文章的结构。

6. 根据文章提供的信息，请完成文章的思维导图（注：思维导图能够展示文章的重要信息）。

7. 请完成文章概述（注：概述为概括这篇文章的重要信息）。

阅读三：

深层海水的利用

①众所周知，海洋中有着丰富的生物和矿产资源，殊不知海水本身也是海洋宝藏之一。海洋学家在长期的研究中发现，深层海水是海洋的精华。若能充分利用深层海水，将会使人类受益无穷。

②所谓深层海水，是指海洋深处的海水。深层海水大量存在于距陆地5000米以外、水深200米以下的地方。在这样的深处，光合作用无法进行，有机物分解的速度远远高于其合成速度，使作为"肥料"的氮、磷、钾等微量元素大都被保存下来，因此它的营养十分丰富，这就为深层海水的利用提供了条件。

③同时，深层海水受海底地形及气象条件的影响，会自然涌升到海面上来。在茫茫大海上，这种被称为"涌升海面"的地方仅占全球海洋面积的0.1％，但却集中了海洋鱼类资源的60％，甚至更多。其奥秘就隐藏在深层海水里：当含有丰富微量元素的深层海水涌上海面后，浮游生物和藻类得以更快生长，为鱼类提供了丰饶的"肥料"。研究表明，涌升海域和一般海域在鱼类产量上的差距极为惊人，单位面积涌升海域的鱼类生产量是沿岸海域的上百倍，是外洋海域的数万倍。如果人类能制造"涌升海面"，将使深层海水资源得到充分的利用，很可能给海洋渔业带来一场深刻的革命。

④深层海水还是一种几乎没有被污染的水，病菌极少。深层海水营养盐浓度是表层海水的5倍，而细菌含量却只有表层海水的1/10甚至1/100。

⑤深层海水在医学领域开始有了用武之地，它已成为一种奇妙的"绿色药品"。医生们用深层海水治疗先天过敏性皮炎，只要在患处涂上深层海水，患者的症状就会得到缓解。**据统计，使用深层海水进行治疗的患者，约有60%收到了良好的疗效。**不过，医生们尚不清楚究竟是深层海水中的什么成分在治疗中发挥了作用。

⑥洁净的深层海水还引起了食品和化妆品生产厂家的极大兴趣。利用深层海水来生产豆腐；酱油、咸菜等，不仅发酵过程加快，而且口感更好。这类产品受到了消费者的青睐，在市场上十分畅销。有些化妆品生产厂家也跃跃欲试，计划利用深层海水开发新一代化妆用品。

⑦深层海水每时每刻都在进行着蔚为壮观的大循环，这种大循环使海洋充满了活力。

⑧生生不息的深层海水给21世纪的人类带来了新的机遇。

1．第③段中与加点词"丰饶"意思相近的词语是＿＿，加点词"肥料"在文中的意思是＿＿。
2．第⑤段的画线句运用了＿＿的说明方法，其作用是＿＿。
3．根据文意，下列理解错误的一项是：
 A．海洋宝藏包括丰富的生物、矿产及深层海水等资源。
 B．人工制造"涌升海面"是为了充分利用深层海水资源。
 C．深层海水中无法进行光合作用，微量元素都被保存下来。
 D．单位面积涌升海域的鱼类生产量是外洋海域的数万倍。
 4．从全文看，深层海水的特点：

1） _____
2） _____
3） _____

它给21世纪的人类带来的新机遇是

1） _____
2） _____
3） _____

5、这篇文章的作者是如何组织文章结构的？请用一句话描述这篇文章的结构。

6. 根据文章提供的信息，请完成文章的思维导图（注：思维导图能够展示文章的重要信息）。

7. 请完成文章概述（注：概述为概括这篇文章的重要信息）。

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阅读四

城市景观花卉装饰

①随着社会的发展和人类文明程度的日益提高，城市景观花卉装饰已逐渐成为评价一座城市的文明程度和综合素质的重要标志。城市居民普遍生活在钢筋水泥的森林里，常常感到压抑，从而有一种内在的返璞归真的需求，而花卉正可以（　　）环境，（　　）性情，（　　）人们的精神生活，所以，花卉装饰作为城市园林造景的主体，备受人们的关注和喜爱，正在得到快速发展，为城市生活创造更加优美的环境。

②城市景观花卉按气候分为热带花卉、副热带花卉、暖温带花卉、冷温带花卉四种；按形态分为草本花卉和木本花卉两种。

③用于花卉装饰的材料主要是盆栽花卉和鲜切花。它们凝聚着大自然的精华，姿态优美，形色各异，用来装饰室内外环境，其效果是其它任何装饰材料所不能替代的。

④用花卉装饰城市景观要讲究设计原则。

⑤就花卉装饰的实用角度而言，布置庆典场所时应选择色彩鲜艳热烈的花卉，使用时间通常是不需要太长的，因此无需考虑花卉材料的耐久性，大多选用花大色艳富丽华贵的插花花篮或盆花，如粉月季、红牡丹等；而布设展览馆或阅览室则要求选用淡雅朴素的花卉，以烘托展品及环境的静谧，而且要求花期或观赏期持久，大多选用盆景、耐久性盆栽花卉，如山石盆景、蕙兰、富贵竹等；布置陵园则要求选用长青、简素的花卉材料，以烘托出庄严肃穆的氛围，如松、柏、黄菊花、白菊花等。

⑥从所需装饰布置的环境特点看，所选用的花材应与环境的色彩、光线的强弱、陈设布局等相适宜。如在广场的入口及建筑的周围，为保证交通、视线、采光等不受影响，可用整齐高大的盆树或盆花，呈对称摆设；也可用色彩艳丽的花草成排成列布置；还可用花卉布置临时花坛、花带等。

⑦从欣赏的角度来说，不同的花材和不同的艺术造型具有不同的观赏效果。观花类的花卉，姹紫嫣红、绚丽多彩，使人感觉温暖、热情、兴奋；观叶类花卉，叶色青翠、叶片舒展，使人感觉宁静、娴雅、清爽；观果类花卉，硕果累累，鲜艳可爱，给人一种丰收的喜悦。插花和盆景的造型，或新异，或优雅，或古朴，更具有诗情画意，使人赏心悦目。

⑧花卉装饰日益成为喜庆迎送、社交活动、生活起居和工作环境的必需。花卉装饰使城市生活更美好。

1.依次填入第1段空格处的词语应是 （　　）

A. 丰富、陶冶、美化　　B. 美化、丰富、陶冶　　C. 美化、陶冶、丰富　　D. 丰富、美化、陶冶

2.依据第一段内容，下列不属于城市景观花卉装饰发展原因的一项是（　　）

A. 社会发展和人类文明程度提高　　　B. 城市居民有一种返璞归真的需求

C. 花卉的现代栽培技术日益成熟　　　D. 花卉装饰可以使城市生活环境更优美

3.第六段运用的说明方法　　　　　　，其作用是　　　　　　　　　　　　。

4.本文围绕城市景观花卉装饰介绍的内容有

（1）城市景观花卉装饰发展的原因；

2）

3）

4）

5. 2010 年 5 月 1 日，学校为庆祝上海世博会开幕，计划在校门口摆放花卉。请根据文中花卉装饰设计

原则，从下表中选择两种最合适的花，并从欣赏的角度写出观赏效果。

花名	花期	花型	花色
菊花	12-5 月	较小	白 黄
大丽花	6-8 月	较小	白 橙 紫
一串红	5-11 月	较小	红 紫
向日葵	6-10 月	大	黄 橙
郁金香	4-5 月	较大	白 黄 粉
水仙花	11-3 月	较小	白 黄
香雪球	3-7 月	较大	红 白 紫

选择花卉：（1）＿＿＿＿＿＿＿(2)＿＿＿＿＿＿＿＿观赏效果：＿＿＿＿＿＿。

5、这篇文章的作者是如何组织文章结构的？请用一句话描述这篇文章的结构。

6. 根据文章提供的信息，请完成文章的思维导图（注：思维导图能够展示文章的重要信息）

7. 请完成文章概述（注：概述为概括这篇文章的重要信息）。

后测二 科技文综述

阅读一

糖尿病

糖尿病顾名思义是病患者尿液中含有糖过高的现象，这是由于胰岛素分泌异常，导致血液中的血糖无法进入细胞二造成血糖、尿糖偏高的疾病。

由于糖尿病患者的身体细胞无法正常运用酶类食物，因而影响到脂肪和蛋白质的代谢。病情若未好好控制，会使许多器官发生功能障碍，而引起全身性的并发症，常见的：神经系统病变、心血管疾病、肾脏病、视网膜剥离等，而是患者身心俱疲。

常见的糖尿病有两型，第一型多发生在儿童及青少年时期，患病原因是自己体内的抗体破坏了胰脏功能，而无法制造胰岛素，大部分的病患必须每天注射胰岛素以维持正常生活。第二型糖尿病多发生在 40 岁以上的中老年人，因身体对胰岛素的反应变差，而使血糖逐渐升高。许多病患都是患病多年才诊断出来的，95%的糖尿病属于此型，而肥胖者与近亲有糖尿病者是高危人群。

糖尿病与许多慢性疾病一样，患病初期并无明显的症状而容易忽略，有一半以上的糖尿病患者完全不知道自己换了糖尿病。患者主要会出现多吃、喝多、尿多的现象，另外也会有体重减轻、容易疲倦、手脚酸麻、皮肤伤口难愈合、视力模糊等症状。而最严重的血糖过高或者过低都会造成昏迷，甚至死亡。

预防糖尿病发生的最好方法，就是培养良好的饮食与运动习惯，并做好体重控制、避免肥胖；另外，经由"验血糖"与"验尿"都可以帮助我们检测自己的身体状况哦。

Q1: 作者是如何组织文章的结构的？请简要说说。

Q2:请完成这篇文章的思维导图（注：思维导图能够反映文章的主要信息）。

Q3: 请完成文章的概述(注：概述为文章的主要内容)。

阅读二

疼痛

　　疼痛是很重啊哟的机制，它可以让我们迅速警觉到身体外在与内部的变化，例如被热水烫到时的疼痛感，以及身体产生病变时的特同感，例如牙痛。有时这些疼痛提供足够的警示后，却欲持续存在；还好人体的神经系统有两套减轻疼痛的机制。

　　第一种机制是分泌脑内咖。脑内咖和玛咖类似，可以阻断或者阻断神经系统中的疼痛的讯息传播。这对于严重、激烈的特痛很有效，但对长期、轻微的疼痛比较无效。

另　　　一种不同于阻断的机制是分散注意。人脑在同一时间内只能处理一定量的信息。例如上课时和同学交谈，就无法同时主要到台上老师的授课内容。同样的，在病人身上施以另一种刺激，可以让脑无法专注在原有的疼痛上这些有些类似"分心"。有时医生会在癌症患者的身上装一种刺激器，借由微量的电流，让人好像有被揉捏的感觉，利用这种错觉分散病人原有的疼痛。

Q1: 作者是如何组织文章的结构的？请简要说说。

Q2:请完成这篇文章的思维导图（注：思维导图能够反映文章的主要信息）。

Q3: 请完成文章的概述(注：概述为文章的主要内容)。

阅读三

光对植物生长的影响

植物的生长发育被多种环境因子所影响，其中包括光、温度、水分等。在这些因子中，光具有特殊重要的地位。因为它不仅影响着植物几乎所有的发育阶段，而且还为光合提供能量。光调节的发育过程包括发芽、茎的生长、叶和根的发育、向光性、叶绿素的合成、分枝以及花的诱导等等。

光对植物种子萌发的影响

光质对种子萌发有影响。白光、蓝光、黄光及黑暗下黄瓜种子能够萌发，红光及绿光的连续照射却抑制黄瓜种子的萌发。有些种类的种子浸在 GA3 中，可以代替光需求，甚至对于不受光影响的种子，这些激素有时也有刺激作用。红光可以增加浸水豌豆的赤霉素含量，远红光减少该激素的水平，而每种光波都能逆转另一种光波的效应，这说明影响种子萌发的光敏素 Pr 和 Pfr 可能在受光刺激后影响了赤酶酸的形成。

光对植物叶片生长的影响

虽然植物叶片（在一段时期内）在黑暗中生长一般和在光下一样快，但在缺光时，双子叶植物叶片不能正常发育。光促进的叶片扩大，主要是由于光照加强了细胞分裂，细胞最终的大小和保持在黑暗中的并没有明显不同。在完整叶片中，亮光下生长的叶片的细胞的分裂伸长的分化速度比在低强度光下更快。光对叶片发育和成熟有一种全面的刺激效果，尤其是双子叶植物。

光对植物茎生长的影响

白天许多植物的茎的伸长速度不及夜间，在很大程度上这是光对生长的抑制作用。在日光下发芽的植物,高强度的蓝光对茎伸长的抑制作用最大，而和它大约相等强度的红光促进伸长。另一方面，在黑暗中发芽时蓝光作用较弱，绿光几乎无效，这说明光对黄化苗和绿苗的影响是不同的，在这 2 种情况下光敏色素所起的效果是不同的。在能量低时，红光比蓝光更具抑制作用，但随着强度增加，蓝光变得更有效。长波长的光（红光）促进茎的伸长，而短波长的光（蓝光）抑制茎的伸长。红光促进细胞的伸长，而蓝光具有相反的效果。虽然已发现蓝光阻止叶柄的伸长，但它可以增加叶片的面积。植物的伸长并不单单是因为红光作用的结果，还与蓝光的缺乏有关，也就是说，蓝光对于使植物健壮是非常必要的。

光对植物开花的影响

一天中白昼和黑夜的相对长度成为光周期。昼夜总长度以 24h 交替出现，但昼夜的长度是因地球的纬度及季节的变化而不同。在各种气象因素中，昼夜长度的变化是季节变换最可靠的信号，生长在地球上不同地区的植物在长期适应和进化过程中表现出生长发育的周期性变化。植物的开花，树木的秋季落叶，芽的休眠以及地下贮藏器官的形成都对昼夜长度的季节变化发生反应，其中光周期对植物成花的反应研究比较深入。

开花受光周期调节的植物达到花熟状态时，在适宜的光周期条件下就可以诱导开花。长日植物一般在比临界日长更长的条件下才能开花，日照越长开花越早，在一定的连续日照下开花最早。短日植物必须在短于临界日长时才能开花，日照缩短，开花提早，但不能短于光合作用对光的需要。各种植物光周期诱导的天数与植物年龄有关，在很多植物中常常看到随年龄的增加，诱导天数减少的现象。植物感受光周期的部位是叶片，叶片对光周期刺激的敏感性与年龄有关，幼叶和老叶的敏感性较差，成长的叶片敏感性最强。

Q1: 作者是如何组织文章的结构的？请简要说说。

Q2:请完成这篇文章的思维导图（注：思维导图能够反映文章的主要信息）。

Q3: 请完成文章的概述(注：概述为文章的主要内容)。

阅读四

让火星变"宜居"的七个大胆设想

在不久前举行的"行星科学展望 2050 研讨会"上,美国国家航空航天局(NASA)提出一个疯狂的想法:在火星周围安置一个巨大的人工磁气圈,以恢复火星的大气层,使其变得宜居。火星是那么的吸引地球人,为了将火星环境"地球化",即把火星改造成接近地球的可供人类移居的环境,科学家提出了不少异想天开的设想。

1．人造磁气圈

火星环境极其恶劣,人类要移民火星必须克服稀薄的大气、超强辐射和极低温度的考验。科学家认为,火星曾经有过厚厚的大气层和炎热的内核。活跃的火山活动促进了大气的循环,炎热的内核能帮助形成驱散太阳风的保护磁场。但数十亿年前,内核冷却,磁场消失,太阳风的剥离使得火星的大气层不断变稀薄,最终沦为一个寒冷、干燥的荒漠。NASA 的新设想提出,将一个"人工磁场"置于火星与太阳之间的轨道,把火星置于"磁尾"的保护之中,使其免受太阳风的侵袭,以便重建被太阳高能粒子剥离的火星大气层。随着大气层不断增厚,火星的温度也将随之升高。温度的升高可令火星极地的干冰融化,释放出大量二氧化碳,形成温室效应。这足以促使火星再次出现液态水,形成河流与海洋。事实上,微型磁气圈的研究已经用于保护宇航员和航天器免受宇宙辐射的影响。科学家则设想形成一个"放大版"的人造磁气圈,并送至太阳和火星之间的拉格朗日点(L1)上。

2．照镜子

除了 NASA 这样的官方机构,许多民间组织也参与到探索火星移民之列,美国火星协会就是其中之一。协会创始人、航天工程师罗伯特·祖柏林认为,改造火星首先要让火星变暖,为此他提出了几个方案。一个方案是在太空中架设巨大反射(或折射)镜群,将更多阳光反射至火星特定区域,以释放出冷冻地表中的气体和液体。不过,要造出和安放如此规模的镜子难度不小。

3．穿黑衣

我们知道,穿黑色的衣服比白色的衣服更吸热。科学家就想到,如果给火星的两极也"穿上黑衣服",即覆盖上一层黑色土壤,那么也助于火星两极的升温。火星被称为"红色星球",黑色的土壤哪里来呢?人们把目光瞄向了火星的两颗卫星。火卫一与火星之间的距离是太阳系所有卫星中与主星距离最近的。不过,如何把"衣服"穿上并且不被火星上的沙尘暴吹走是一个大问题。

4．扔核弹

特斯拉和 SpaceX 公司的首席执行官埃隆·马斯克曾语出惊人,称可以往火星两极扔核弹,来改造火星大气。理论上,爆炸后释放的大量热量,可以融化火星两极的冰层和释放被锁住的二氧化碳,迅速增加火星大气层的厚度,触发温室效应,逐渐使火星变成一颗宜居行星。但是,科学家并不很认同这一方法,认为这不仅会不可逆转地改变火星的地表形态,甚至会导致与预期相反的情况出现,即不是升高而是降低火星温度,因为核弹会在火星造成"核冬天"。

5．小行星撞击

太空中很多小行星都是由冷冻的氨气构成的,而氨气则是重要的温室气体。如果科学家能抓住或者重新定向一颗小行星,让它撞击火星,撞击产生的巨大能量将使火星上的冰融化成水,二氧化碳也被释放出来,所释放的氨气也可以让火星大幅升温。

6．人造温室效应

在地球上,人类几乎是谈温室效应色变,而对火星,科学家则是想方设法要制造出温室效应。根据研究,四氟化碳是最有效的温室气体。科学家想到在火星建几座制造温室气体的化工厂,不间断地生产四氟化碳一类的氟氯烃以及甲烷、氨气、二氧化碳、水蒸气等。根据计算,如果每小时排放 1000 吨四氟化碳,30 年内火星的平均温度将升高 27.8℃。生产过程预计耗能 5000 兆瓦,5 个核电站可以满足能量需求。

7．播种蓝藻

目前火星大气中 96% 为二氧化碳。科学家设想把蓝藻播种到火星,用它们将火星大气中的二氧化碳转化成氧气。科学家认为,正是蓝藻等藻类将早期地球上的有毒气体转化为氮和富含氧气的大气,并且促进了臭氧层的形成,为地球生命的诞生创造了有利条件。他们希望这一过程也能发生在火

星上。科学家计划不久之后通过无人探测器在火星进行一项测试，验证转化火星大气成分的技术。NASA 和其他空间机构也在研究生物改造火星大气的可能性，国际空间站上已经开展了蓝藻实验。蓝藻的基因需要被改造，使其能够耐受宇宙中的极端环境。

Q1: 作者是如何组织文章的结构的？请简要说说。

Q2:请完成这篇文章的思维导图（注：思维导图能够反映文章的主要信息）。

Q3: 请完成文章的概述(注：概述为文章的主要内容)。

English Translation of All Researcher-developed Tests

Posttest 1: Chinese Comprehension Test and Comprehension Test on Generic Texts

Directions: Please read the passages and answer the questions about it.

P1:

<div align="center">Chinese Red</div>

From all the colors, we can find that Chinese Red is the best color for Chinese people to celebrate their festivals. Yellow, although it is warm and bright but it is always related to the imperial power, it is not suitable for holidays. White, which is pure and elegant with a poetic romance, it is also not good color for the special days of celebrating. Purple is low-key, glamorous, mysterious, elegant, romantic; however, it also does not match the warm atmosphere of festivals. Green is the symbol of hope and vigorous life, but it is too cool to be the main color of the holiday.

The red is the best. It strikes your eyes when you first saw it. It is also the most vibrant color, sending you a message with endless passion and power. Red is also the most enthusiastic, most lively, the most spiritual color, which can make you impressive when you even have a glance on it. It is the best color for the festivals.

From the perspective of wavelength, we can also find that red is the best one for festivals. Optical experiments indicated that: the shorter the wavelength of light is, the stronger the scattering effect it will be; the longer the wavelength of light is, the weaker the scattering effect it will be. From all of the visible lights, red has the longerst wavelength and weakest effect of scattering. This means red color can travel to the furthest of human sight. The further, the better. This perfect fits the needs of festivals.

Another important fact that people like red is from the perspective of survival theory. It is indicated that the feeling of color is innate. When we observe things around us, we will pay attention to color, shape, lines and points respectively. Therefore, color is the first thing that our eyes can perceive.

The importance of red can also be supported by the studies that were conducted by researchers from Hong Kong University. They observed the eating habits of primates living in the Kibale National Park in Uganda and found that Apes and Monkeys usually use blue and yellow light to choose the fruits they would like to eat; _____, if they want to eat the fresh leaves with more nutrition, they need to distinguish the red color from the green, _____ , fresh leaves contains a slight red, which can help animals to distinguish those fresh ones from the others. Red brings the excitement and joy and stimulates animals' visual nerves. In short summary, the sensitivity to the red of primates animals could relate to their food-hunting habits.

Chinese red also reflects the mystery of the oriental culture. The origins of oriental culture can be traced back to the worship of Sungod of ancient Chinese. Such worship of Suggood has been kept in China for thousands of years as the cultural totem. Therefore, the favoring of red reflects the cultural psychology of Chinese of the sun.

Chinese red is also an important part of Chinese culture. Every community has its own tradition. However, the formation of each tradition was selective. First, it should be acceptable to most people in the country, and then it will get spread until it became the collective mindset. After this, the reinforce effects will make such costume get deep into everyone in the community. This is how the red developed into one of the most important color in Chinese culture as well as the main color in all of our major holidays.

In one word, Chinese Red, as well as some other important colors, including Chinese porcelain Blue, Locust Green, Great Wall Grey, Ink Black and Jade White are all important tradition colors in Chinese culture.

Please answer following questions about this passage:

1. How does the author organize the information in the paragraph 1 and 2? Why?

2. In paragraph 4, there is a word "respectively". Can you delete the word? Why?

3. Please fill in the words in the blanks in paragraph 5:

   A. only because

   B. although but

   C. Even But

   D. if because

4. Please give two examples about using red color in Chinese daily life.

5. How does the author organize the information of this passage?

6. Please draw a graphic organizer and write down important information in the GO.

7. Can you write a summary about the passage? (Please writing down those important

   information as much as possible)

Chinese Porcelain

Chinese porcelain is one of the greatest inventions in the world. It is famous because of its unique technology on material, enamel and firing.

Most Chinese porcelain has a certain degree of transparency, with the so-called jade-like appearances. The raw material of Chinese porcelain is Kaolinite, which can be found from southeast coast to middle west in China and especially around the city Jingdezhen. The richness of those raw materials makes the possibility of the booming of the porcelain industry in China.

Enamel technology is another important milestone in the history of Chinese porcelain. During the Song Dynasty, the reason that Jingdezhen became the most important city of porcelain industry is due to its innovation of enamel technology. Artists in Jingdezhen started to apply dolomite into enamel of their products. That material can keep the body of porcelain body shining but can be easily glazed.

Firing temperature is the temperature that the ceramic wares are heated in a kiln to permanently set their shapes. Pottery or tiles can be made under the temperature below 1000 °C. However, for Chinese Porcelain, the firing temperature should be around 1200°C. Shigenobu Kimura described this technology in his book about Chinese ceramics: "Even though the porcelains are firing at the temperature more than 1300°C, all of the patterns and glazing decorations can keep in their original designs. This is the most important technology of Chinese Porcelain. "

The success of Chinese porcelain in the world is also due to the integration of the advanced technology with folk arts. The decoration of fine porcelain in China has been developed into a complex system during a long history period. No matter it is decorative cutting, Jacquard weaving, appliqué, printing or gold plating, all of them _____. In the earlier stage, those decorations are simple and natural, using the patterns such as the waves, clouds, flowers or animals. During the Tang Dynasty, artists borrowed the ideas from the vessels and weaves and started to apply more complicated patterns on the ceramics. The artistic pursuing on the decoration of porcelain went to the peak during the Song Dynasty. Every single ware was made as an artistic work, with a special name such as the Sparkle of a Mountain Stream, the Spring Blossom, the Snow Branches, or the Starry Sky, etc.

Chinese Porcelain also delivers messages of luxuriant history to China. Many folk stories have also been found on the wares, such as Rhino under the Moon, the Luck with Dragon and Phoenix and _____ . For example, there was a set of flower wine cups made by Jingdezhen during Kangxi Emperor. Each cup was painted with a flower as well as the poem that matched the flower. Therefore, for the cup with plum blossom, there was a poem " the snow, white and pure; freeze the tree; the fragrance, with a breeze, fully filled on the branches. " on it. For the cup with apricot blossom, the poem glazed on was "overnight rain brings the green incense; after the mist is gone, it comes the best picture of the day." The cup with peach blossom has the poem "spring breeze brings the blossoms and the newborn swallow, the best time of the season. " etc. In a word, those fine porcelain cups with delicate pictures and beautify words make them a piece of phenomenal artwork.

Please answer following questions about this passage:

1. Fill in the blank in Paragraph 5:

2. Read paragraph 5, what is the structure that the author used to organize the information for the paragraph?

3. Fill in the blank in paragraph 6.

4. According to the article, please write down the reasons that people love Chinese Ceramics?

5. How does the author organize the information of this passage?

6. Please draw a graphic organizer and write down important information in the GO.

7. Can you write a summary about the passage? (Please writing down those important information as much as possible)

The Utilization of the Deep Ocean Water (DOW)

As we all know, the ocean is rich in biological and mineral resources. However, the water itself is also one of the most important treasures for human beings. Oceanographers strongly suggested that we should take advantage of the DOW as it can bring tremendous benefits for us.

The DOW is the water that below the surface of Earth's oceans. Usually, we refer the DOW as the water that is 5000 meters away from the main lands and 200 meters below the sea surface. In the deep ocean at this level, there is no photosynthesis. Moreover, the decomposition rate of organic matter is much faster than its synthesis speed at this level and thus most of trace element such as nitrogen, phosphorus, potassium and other trace elements are preserved as "fertilizer". Therefore, the water in the deep sea is rich on nutritions and could be an ideal source for human to utilize.

Meanwhile, the water in the deep sea will be affected by the weather or the terrains and might come up to the surface, which is called as "upwelling". It has been indicated that only 0.1% surface of the ocean is the upwelling, but those places contain 60% fish of the whole ocean. The reason is obvious, the richness of phytoplankton and algae in these areas provide enough food for fish to live in. in addition, studies showed that the production of fish is also remarkable different between the upwelling areas and the normal parts. It is found that the fish product from the upwelling is 100 times more than that from the costal areas and 100000 times than that from the oceanic zone. Therefore, it will bring a fundamental change of fishing industry if we can take advantage of the upwelling areas of our oceans.

The deep-sea water is also clean, unpolluted water, with little germs. The level of salt concentration is much higher in the deep sea, which is approximately 5 times than that of the surface water. Therefore, the germs that live in there is only 1/10 or 1/100 of that in the surface water.

DOW has also been used in medical areas, since it can be used as a magical "green medication". Doctors use DOW to treat some dermatitis. It is reported that when they apply the water into the infection areas of patients and the symptoms will be alleviated greatly. However, doctors still have no idea the mechanism of the DOW treatment.

In addition, People from the food industry and cosmetic industry showed their great interest in DOW. It is found that if food such as tofu, soy sauce and pickles were produced using DOW is tasted much better and has been favored by consumers. Cosmetic companies also tried to developed new products using DOW.

In a short word, DOW brings lots of possibilities for our future.

Please answer following questions about the passage:

1. In the paragraph 2, What is the meaning of "richness", what is the meaning of "fertilizer"

2. Please find the sentence with underline in the paragraph 5. What is the purpose of the sentence in the paragraph? Why the author wrote this sentence?

3. What is nor correct according to the passage:

a. The ocean is full of the resources of organism, minerals and DOW.

b. Human can make the upwelling of ocean water to get more resources from the sea.

c. This is no photosynthesis in the deep water; therefore, all of the trace elements were preserved.

d. The upwelling areas can produce 10000 times more fish than that of the oceanic zone.

4. What is the features of DOW:

   a. _____ .

   b. _____ .

   c. _____ .

   What are the challenges that DOW brings:

   d. _____ .

   e. _____ .

   f. _____ .

5. How does the author organize the information of this passage?

6. Please draw a graphic organizer and write down important information in the GO.

7. Can you write a summary about the passage? (Please writing down those important information as much as possible)

P4

Floral Landscaping in the Urban City

The development of modern cities requires the needs for floral landscaping. Residents who live in the concrete forest in the modern cities are eagerly looking for the environment that can bring them back to the nature. Floral plants can help them on _____. Therefore, the city landscape becomes one of the most important topics in today's city life.

There are many types of floral landscape. According to the different types of temperature that flowers live, the landscaping can use tropic flowers, subtropical flowers, warm temperature flowers and cold temperature flowers. In addition, landscaping can also use herb flowers or woody flowers based on the needs of different shapes.

The flowers that used for landscape in the city are potted plants or fresh cut flowers. They are fresh, colorful and beautify with many different shapes, thus are the best decoration of a city.

All of the floral landscape requires being well designed.

The first rule for the decoration design is to look at the occasion that the flowers are needed. If the flowers are needed to celebrate special occasions, then it is better to choose the flowers with bright colors. In addition, since the celebration usually won't take too long, it is ok if you choose the flowers that can only blossom for short period such as roses or peonies. If the flowers will be used to decorate the places such as reading rooms in library or the lobby of an art museum, the plants such as orchids or lucky bamboo would be a good choice.

The second thing that you should pay attention to is about the background environment of the landscape. The flowers should matches the color of their background and the lights it could be. For example, if you are decorating the entrance of the square or a building, you should pick big plants and place them symmetrically on the entrance, and make sure your plants won't block the way.

The last but most important, your decoration should show artistic effects. If you are trying to make an atmosphere of warm and welcoming, then you should choose the flowers with bright colors. If you decorate your place for peaceful atmosphere, then you can choose the green plants. If your purpose is to make people feel happy, you can arrange some fruits. In addition, miniascapes are also good choice for some specially occasions that you would try to make an antique sense.

In a word, floral decoration is one of the most important things in our daily life. It makes our city lovely.

Please answer following questions about the passage:

1. Please fill in the words in the paragraph:

2. Please read the paragraph one and find the reasons that not contribute to the development of landscaping of urban city:

   a. The development of the city

   b. Residents want to return to the nature

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  c. The development of technology on floral landscape

  d. The landscape can make life better.

3. Please read paragraph 6. How the author was organizing this paragraph? Why?

4. The main points of the passage:

  a. The history of the floral landscape

  b. _____ .

  c. _____ .

  d. _____ .

5. 7. There will be a flower show in your school on May 1st. Please read the information about the flowers and pick two of them as the decoration flower of your school.

Name	Blossom season	Size	Color
Chrysanthemum	Dec-May	small	white, yellow
Dahlia	Jun-Aug	small	white, yellow, orange
Scarlet sage	May- Nov	small	red, purple
Sunflower	Jun-Oct	big	yellow, orange
Tulip	Apr-May	small	white, yellow, pink
Daffodil	Nov-Mar	small	white, yellow
Alyssum	Mar-Jul	medium	red, white, purple

6. How does the author organize the information of this passage?

7. Please draw a graphic organizer and write down important information in the GO.

8. Can you write a summary about the passage? (Please writing down those important information as much as possible)

Posttest 2 Science Text Summarization Test

P1

<div align="center">Diabetic</div>

The body of people with diabetes is unable to fully break down carbohydrate; the dysfunction also affects the metabolism of other nutrients, like lipids and proteins. If the illness is not adequately controlled, some functional disabilities of organs may occur. Furthermore, it may cause many complications for the whole body, like diabetic neuropathy, cardiovascular diseases, kidney disease, and retinal detachment and so on. Some patients are exhausted both physically and emotionally.

There are 2 main forms of diabetes, type 1 and type 2. Type 1 diabetes is usually diagnosed in children and young adults. Because the antibody of the patient's body destroys the function of pancreas, the pancreas is unable to produce insulin. Most people with diabetes need insulin shots daily to have normal lives. Type 2 diabetes is common in the old and in middle-aged people over 40 years old. The body doesn't respond well to insulin, and the defects cause high blood sugar levels. Most patients have had diabetes for many years before they are diagnosed. 95 percent of people with diabetes are the patients with type 2. The obese ones or people with family history of diabetes are at risk for diabetes.

Like a chronic illness, initially the symptoms are subtle and may be neglected easily. More than half of the people with diabetes don't know that they have diabetes. The symptoms developing on the patients include the "triad," which means "increased appetite, fluid intake and excessive urine;" in addition, weight loss, a feeling of easily being tired, the sense of weak and numb limbs, poor healing of wounds, blurred vision and so on. Sometimes the seriously high or low blood sugar leads to the loss of consciousness, even death.

The best way to prevent diabetes is to develop a healthy diet, have regular exercise, and control weight, which may help avoid obesity. Besides, we can monitor our health with the help of "glucose tests" and "urine tests."

Q1: How does the author organize the information of this passage?

Q2: Please draw a graphic organizer and write down important information in the GO.

Q3: can you write a summary about the passage? (Please writing down those important

information as much as possible)

P2

Pain

Pain serves an important function of the human body. Pain rapidly gives us warning of the change of environments outside of the body, like the pain of being scalded with hot water; and the malfunction of the body, like toothache. Sometimes the pain lasts for a while even though the alert should be lifted. Luckily, pain can be relieved by the human nervous system with two mechanisms.

The first mechanism is the secretion of endorphin. Endorphin is similar to morphine, which can interrupt or partially interrupt the transmission of pain-related information. This method is very effective for severe, acute pain, but less effective for chronic, mild pain.

The other different mechanism is to draw away attention. The brain can only process limited amounts of information at one time. For example, when one is talking to a classmate in class, he can't concentrate on what the teacher says. Similarly, giving another kind of stimulus to a sufferer of pain can make the brain unable to focus on the original pain. This condition is like "distraction." For cancer pain, sometimes the doctor uses this technique to treat the pain, which may be reduced by placing the electrodes on the patient's skin. A low-voltage current is transmitted to the body, and a tingling sensation is felt. This can help distract the patient from the original pain.

Q1: How does the author organize the information of this passage?

Q2: Please draw a graphic organizer and write down important information in the GO.

Q3: can you write a summary about the passage? (Please writing down those important

information as much as possible)

Light for Plants

The growth and development of plants are affected by various environmental factors, including light, temperature, water and so on. Among these factors, light plays a particularly important role. It not only affects almost all stages of plant development, but also provides energy for photosynthesis. Light regulation processes include germination, stem growth, leaf and root development, phototropism, chlorophyll synthesis, branching and flower induction.

Effect of light on seed germination

Light quality has an effect on seed germination. Cucumber seeds germinated under white light, blue light, yellow light and dark, but the continuous irradiation of red light and green light inhibited the germination of cucumber seeds. Some types of seeds, soaked in GA3, can replace light requirements, and even seeds that are not affected by light can sometimes be stimulated by these hormones. Red light can increase the content of gibberellin in water-soaked peas, while far-red light reduces the level of this hormone, and each light wave can reverse the effect of another light wave, which indicates that the photosensitive hormone Pr and Pfr that affect seed germination may affect the formation of gibberellin after being stimulated by light.

The effect of light on the growth of plant leaves

Although leaves of plants generally grow as fast in darkness as in light, dicotyledonous leaves do not develop normally in the absence of light. Light promotes leaf enlargement, mainly because light intensifies cell division, and the final size of cells is not significantly different from that of those kept in the dark. In intact leaves, cells that grow in bright light divide, elongate and differentiate faster than those that grow in low light. Light has an overall stimulating effect on leaf development and maturation, especially in dicotyledonous plants.

The effect of light on the growth of plant stems

The stem of many plants does not elongate as fast during the day as it does at night, largely because light inhibits growth. In plants germinating in sunlight, high-intensity blue light has the greatest inhibitory effect on stem elongation, while approximately equal intensity red light promotes elongation. On the other hand, blue light plays a weak role in germination in dark, and green light is almost ineffective, which indicates that light has different effects on yellowing seedlings and green seedlings, and photosensitive pigment has different effects in these two cases. At low energies, red light is more inhibitory than blue light, but as the intensity increases, blue light becomes more effective. Long wave length light (red light) promotes stem elongation, while short wave length light (blue light) inhibits stem elongation. Red light promotes cell elongation, while blue light has the opposite effect. Although blue light has been found to prevent petiole elongation, it can increase leaf area. The elongation of plants is not only due to the action of red light, but also to the lack of blue light, which is necessary to make plants strong.

The effect of light on the flowering of plants

The relative length of day and night in a day becomes the photoperiod. The total length of day and night alternates in 24 hours, but the length varies with the latitude of the earth and the seasons. Among various meteorological factors, the change of day and night length is the most reliable signal of seasonal change. Plants growing in different regions of the earth show periodic changes in growth and development in the long-term adaptation and evolution process. The flowering of plants, the autumn deciduous leaves of trees, the dormancy of buds and the formation of underground storage organs all respond to the seasonal changes in the length of day

and night, among which the photoperiod has been deeply studied in response to the floral formation of plants.

Flowering plants regulated by photoperiod can be induced to bloom when they reach the ripe state of flowers under appropriate photoperiod conditions. Long-day plants generally can blossom under longer conditions than the critical day. The longer the sunshine, the earlier the flowering, and the earliest flowering under certain continuous sunshine. Short day plants must be shorter than the critical length of the day before flowering, sunshine shortened, early flowering, but not shorter than light cooperation with the need for light. The number of days induced by photoperiod in various plants is related to the age of plants. The photoperiod is sensed by plants in leaves, and the sensitivity of leaves to photoperiod stimulation is related to age. The sensitivity of young leaves and old leaves is poor, and the sensitivity of growing leaves is the strongest.

Q1: How does the author organize the information of this passage?

Q2: Please draw a graphic organizer and write down important information in the GO.

Q3: can you write a summary about the passage? (Please writing down those important

information as much as possible)

Mars

At the recent planetary science outlook 2050 symposium, NASA came up with the crazy idea of placing a giant artificial magnetosphere around Mars to restore the planet's atmosphere and make it habitable. Mars is so attractive to earthmen that scientists have come up with some fantastic ideas to "Terraforming" of Mars, that is, to transform it into an environment close to earth where humans can migrate.

1. Artificial magnetosphere

The environment on Mars is extremely harsh. To migrate to Mars, humans must overcome the tests of thin atmosphere, ultra-strong radiation and extremely low temperature. Scientists believe that Mars once had a thick atmosphere and a hot core. Active volcanic activity circulates the atmosphere, and the hot core helps create protective magnetic fields that dissipate the solar wind. But billions of years ago, when the core cooled, the magnetic field disappeared and the solar wind stripped away, Mars' atmosphere thinned out into a cold, dry desert. NASA's new idea is to put an "artificial magnetic field" in orbit between Mars and the sun and shield Mars from the solar wind with a "magnetic tail" to reconstruct the Martian atmosphere stripped away by the sun's high-energy particles. As the atmosphere thickens, so will the temperature of Mars. Rising temperatures could melt dry ice at Mars' poles, releasing large amounts of carbon dioxide and creating a greenhouse effect. That's enough to cause liquid water to reappear on Mars, forming rivers and oceans. In fact, research on micro-magnetospheres has been used to protect astronauts and spacecraft from cosmic radiation. Scientists envision forming a "scaled-up" version of the man-made magnetosphere and sending it to the Lagrange point (L1) between the sun and Mars.

2. Look in the mirror

In addition to official agencies like NASA, many civil society organizations are also involved in exploring the migration to Mars, including the American Mars society. Robert Zublin, an aerospace engineer and founder of the society, has proposed several ways to change Mars to make it warmer. One idea is to set up huge clusters of reflecting (or refracting) mirrors in space to reflect more sunlight back to specific areas of Mars, releasing gases and liquids from the frozen surface. However, it is difficult to build and place mirrors of this size.

3. Wear black

We know that wearing black clothes absorbs more heat than wearing white clothes. Scientists have thought that if the planet's poles were also "dressed in black," or covered with a layer of black soil, it would also help warm them up. Mars is called "red planet", where does the black soil come from? Eyes were fixed on the two moons of Mars. Phobos is closest to Mars than any other moon in the solar system. However, how to put on the "clothes" and not be blown away by dust storms on Mars is a big problem.

4. Throwing a bomb

Tesla and Elon musk, the chief executive of SpaceX, have made a stunning claim that they can change the atmosphere of Mars by dropping nuclear bombs at both poles. In theory, the large amount of heat released after the explosion could melt the ice at the poles of Mars and release locked carbon dioxide, rapidly thickening the atmosphere of Mars, triggering the greenhouse effect and gradually making Mars a habitable planet. However, scientists do not agree with this method, believing that it will not only irreversibly change the surface morphology of Mars, but even lead to the opposite of what is expected, that is, to lower the temperature of Mars instead of raising it, because nuclear bombs will cause a "nuclear winter" on Mars.

5. Asteroid impact

Many asteroids in space are made of frozen ammonia, an important greenhouse gas. If scientists could grab or redirect an asteroid to hit Mars, the energy from the impact would melt the planet's ice into water, releasing carbon dioxide and releasing ammonia that could heat the planet up significantly.

6. Man-made greenhouse effect

On earth, humans are almost talking about the greenhouse effect, and on Mars, scientists are trying to create a greenhouse effect. According to the study, carbon tetrafluoride is the most effective greenhouse gas. Scientists have come up with the idea of building chemical plants on Mars to produce greenhouse gases, including chlorofluorocarbons (CFCS), like carbon tetrafluoride, as well as methane, ammonia, carbon dioxide and water vapor. According to the calculation, if emissions per hour 1000 tons of carbon tetrafluoride, Mars 30 years average temperature will rise by 27.8 °C. The production process is expected to consume 5,000 megawatts of energy, and the five nuclear power plants will be able to meet the energy demand.

7. Sow cyanobacteria

Mars currently has 96 percent carbon dioxide in its atmosphere. Scientists envision seeding cyanobacteria to Mars and using them to turn carbon dioxide in the Martian atmosphere into oxygen. Scientists believe algae, such as cyanobacteria, converted toxic gases from the early earth into nitrogen and an oxygen-rich atmosphere and helped create the ozone layer, creating favorable conditions for life on earth. They hope the same process will happen on Mars. Scientists plan to conduct a test on Mars soon using an unmanned probe to verify the technology used to transform the composition of the Martian atmosphere. NASA and other space agencies are also studying the possibility of bioengineering Mars' atmosphere, and cyanobacteria experiments have been carried out on the international space station. Cyanobacteria need to be genetically engineered to withstand extreme conditions in the universe.

Q1: How does the author organize the information of this passage?

Q2: Please draw a graphic organizer and write down important information in the GO.

Q3: can you write a summary about the passage? (Please writing down those important

information as much as possible)

APPENDIX F

The Chinese Readability Formula

The readability score of texts used in this study is calculated using the following formula:

Readability (Y) = 8.76105604

+ 0.00272438 * Length of the text (Xl)

+ 0.07866782 * Average length of sentences (X2)

- 8.94311010 * Chinese character frequency (X3)

+ 0.42920182 * Written in poetic format (X4)

+ 3.23677141 * Written in classic Chinese (X5)

APPENDIX G

Examples of Scoring Rubrics

Table G1

An Example of Scoring Rubric for Knowledge of Text Structure

	Passage	Identification of Text Structure			Graphic Organizer of Text Structure		
		Full Credit:	Partial Credit	No Credit	Full Credit	Partial credit	No Credit
Science Text	Diabetic	CE/DS/PS	The description of the type of structure includes words about text structure, such as cause, effect, problem, description.	Other types of text structure, such as main idea-detail-main detail, or describe the structure by summarize each paragraph	A GO includes title, main idea (MI) and some elements of TS information with clear identification, such as the causes and the effects, the example and its features or the problems and its solutions.	A Go includes title and main ideas sentence OR some elements of TS with clear identification.	None of TS structure elements (title were included in GO, include Title, MI and their relationships)
	Pain	DS					
	Plant	DS/CS					
	Mars	PS/DS					
	Red	CS/DS					
Generic Text	Porcelain	DS/CS					
	Water	DS/CS/PS					
	Landscape	DS/CS					

Table G2

An Example of the Scoring Rubric for Text Summary of the Texts

Full Credit	Partial Credit
Science P1: Diabetic	
Diabetic	
Diabetes is a syndrome with the defects of insulin secretion, which causes the blood sugar may not be taken into the cells and high level of glucose in blood and urine.	1) Diabetes is a syndrome with the defects of insulin secretion; or 2) which causes the blood sugar may not be taken into the cells: or 3) and high level of glucose in blood and urine.
Type 1 happens among children and adolescents	
The patients are not able to produce insulin and need daily insulin shots	The patients are not able to produce insulin; or need daily insulin shots
Type 2 occurs among middle-age and old age people	
Body's response to insulin getting worse and cause the increase of blood glucose level.	Body's response to insulin getting worse/ or cause the increase of blood glucose level.
symptoms: increased appetite, fluid intake and excessive urine; the sense of weak, numb limbs, poor healing of wounds, blurred vision, and even loss of consciousness and death	
Patients' metabolism of lipids and proteins is also affected	
Therefore, there might be some complications in heart, vision and kidney	
The prevention of diabetes includes healthy diets and exercise.	

Table G3

An Example of Scoring Rubric for GO/important ideas of the Texts

Full credit	Partial credit
Science P1: Diabetic	
Diabetes	
Diabetes is a disease with the defects of insulin	
secretion	Insulin
sugar in the blood can not be taken into the cells	
High glucose in blood and urine	
unable to break down carbohydrate	
Metabolism of lipids and proteins is also affected	
organs disabilities/complications	
	pancreas's function was
the function of pancreas was destroyed by antibody	destroy/ destroyed by antibody
unable to produce insulin	
insulin shots	shorts
Type 1: in children and adolescents	
response to insulin getting worse	
Glucose level getting higher gradually	high glucose level
Type 2: middle-age and old people	
symptoms: subtle at the beginning, and later increased	
appetite, fluid intake and excessive urine	
more symptoms: the sense of weak, numb limbs, poor	
healing of wounds, blurred vision, even loss of	
consciousness and death	only one of the symptom
Preventions: healthy diet and regular exercise	diet/exercise

Original ANCOVA Outputs from SPSS for All Outcome Measures

Table H1

Descriptive Statistics: GO/important ideas, Science

Condition	Mean	Std. Deviation	N
Treatment	30.51	16.13	40
Control	23.96	11.89	44
Total	27.08	14.36	84

GO: Graphic Organizer.

Table H2

Tests of Between-Subjects Effects: GO/important ideas, Science

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.243[b]	3	.081	4.409	.006	.142
Intercept	.003	1	.003	.176	.676	.002
PISA reading pretest	.081	1	.081	4.391	.039	.052
PISA science pretest	.061	1	.061	3.315	.072	.040
Condition	.139	1	.139	7.577	.007	.087
Error	1.469	80	.018			
Total	7.871	84				
Corrected Total	1.712	83				

[a]GO: Graphic Organizer. [b]R Squared = .142 (Adjusted R Squared = .110)

Table H3

Descriptive Statistics: Text Summary, Science

Condition	Mean	Std. Deviation	N
Treatment	14.97	13.63	40
Control	5.40	7.19	44
Total	9.96	11.72	84

Table H4

Tests of Between-Subjects Effects: Text Summary, Science

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.211[a]	3	.070	6.053	.001	.185
Intercept	1.291E-6	1	1.291E-6	.000	.992	.000
PISA reading pretest	.005	1	.005	.435	.511	.005
PISA science pretest	.012	1	.012	1.065	.305	.013
Condition	.187	1	.187	16.118	.000	.168
Error	.928	80	.012			
Total	1.972	84				
Corrected Total	1.139	83				

[a]R Squared = .185 (Adjusted R Squared = .154)

Table H5

Descriptive Statistics: GO/important ideas, Generic

Condition	Mean	Std. Deviation	N
Treatment	37.97	15.81	42
Control	27.98	13.00	45
Total	32.80	15.19	87

[a]GO: Graphic Organizer

Table H6

Tests of Between-Subjects Effects: GO/important ideas, Generic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.218[a]	2	.109	5.191	.007	.110
Intercept	.223	1	.223	10.587	.002	.112
PISA reading pretest	.001	1	.001	.063	.802	.001
Condition	.181	1	.181	8.612	.004	.093
Error	1.767	84	.021			
Total	11.347	87				
Corrected Total	1.985	86				

[a]R Squared = .110 (Adjusted R Squared = .089)

Table H7

Descriptive Statistics: Text Summary, Generic

Condition	Mean	Std. Deviation	N
Treatment	27.17	19.30	42
Control	9.23	9.28	45
Total	17.89	17.404	87

Table H8

Tests of Between-Subjects Effects: Text Summary, Generic

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.701[a]	2	.350	15.455	.000	.269
Intercept	.082	1	.082	3.604	.061	.041
PISA reading pretest	.002	1	.002	.092	.762	.001
Condition	.593	1	.593	26.171	.000	.238
Error	1.904	84	.023			
Total	5.390	87				
Corrected Total	2.605	86				

[a]R Squared = .269 (Adjusted R Squared = .252)

Table H9

Descriptive Statistics: Chinese Reading Comprehension Test

Condition	Mean	Std. Deviation	N
Treatment	68.95	14.13	42
Control	71.74	7.81	45
Total	70.39	11.33	87

Table H10

Tests of Between-Subjects Effects: Chinese Reading Comprehension Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.018[a]	2	.009	.680	.509	.016
Intercept	.912	1	.912	70.555	.000	.457
PISA reading pretest	.001	1	.001	.051	.822	.001
Condition	.017	1	.017	1.329	.252	.016
Error	1.086	84	.013			
Total	44.214	87				
Corrected Total	1.104	86				

[a]R Squared = .016 (Adjusted R Squared = -.007)

Table H11

Descriptive Statistics: PISA Reading, Posttest

Condition	Mean	Std. Deviation	N
Treatment	74.3293	9.47075	41
Control	75.3488	6.39897	43
Total	74.8512	8.01308	84

Table H12

Tests of Between-Subjects Effects: PISA Reading, Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	83.844[a]	2	41.922	.647	.526	.016
Intercept	8092.447	1	8092.447	124.961	.000	.607
PISA reading pretest	62.027	1	62.027	.958	.331	.012
Condition	2.319	1	2.319	.036	.850	.000
Error	5245.546	81	64.760			
Total	475956.250	84				
Corrected Total	5329.390	83				

[a]R Squared = .016 (Adjusted R Squared = -.009)