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Using Technology to Support Expository Reading and Writing in Science Classes

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ABSTRACT Students struggle with the transition from learning to read narrative text in the early grades to reading expository text in the science classroom in the upper grades as they begin reading and writing to gain information. Science teachers can adapt their teaching materials to develop students' reading comprehension and recall by writing summaries of scientific text. Using technology, teachers can scaffold text comprehension and improve students' reading and writing skills. Technology encourages improved comprehension of reading and more elaborate writing in the science classroom by motivating students to act on their curiosity, access resources, and embellish their work.

KEYWORDS comprehension, expository text, multimedia literacy, reading skills, technology, writing in science

Successful science programs reflect a balanced, comprehensive approach to teaching that includes direct instruction of reading, along with the teaching of investigation skills (California Department of Education 2004). Effective science teaching must focus on expository or informational text, the language through which school knowledge is constructed (Fang 2008). However, teaching elementary and middle school students to read and write expository texts in science can be a difficult task. Students struggle with the transition from learning to read narrative in the early grades to using exposition in the upper-elementary and middle school grades as they begin using reading and writing to gain information (Carrier 2005). Most textbooks provide few literacy exercises for developing students' reading and writing in science. Science teachers can no longer rely solely on their textbooks to provide students with practice in reading and writing. By including multimedia resources to engage students' curiosity, teachers can increase science learning from a variety of expository texts. However, expanding textual resources requires new teaching strategies to guide students as they navigate increasingly complex texts.

Reading, writing, and vocabulary instruction still comprise the foundational toolkit for acquiring knowledge in all its forms (McKeown, Beck, and Blake 2009). Science textbooks, media, trade books, and Web sites challenge students' comprehension skills in new ways. Science teachers can meet these challenges by designing exercises that scaffold the reading and writing of informational or expository text and the acquisition of new vocabulary.

This scaffolding needs to integrate reading, writing, and vocabulary instruction. One means for achieving this end is the modified sentence-completion

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TABLE 1 **Paragraphs Exemplifying Several Expository Text Structures**

Type	Example
Problem–Solution	When a sheep falls down, it cannot get up again by itself. A sheep has a heavy body but delicate legs. When it is lying on its back, it is weighed down by its thick heavy fleece. Even waving its legs does not help. Its legs are too thin and weak to swing its heavy body onto its side. A shepherd has to help the sheep onto its feet.
Comparison–Contrast	Crocodiles and alligators are similar in many ways but different in others. Both have tough hides, which are wanted by manufacturers of leather. Both prey on fish and small mammals that they swallow whole. The crocodile seems the more menacing of the two, because it shows more teeth when its mouth is closed. Still, nobody would want to encounter either one of these creatures alone.
Cause–Effect	The lack of gravity makes even simple tasks a challenge. Astronauts have to wear boots that hold their feet to the floor so they can walk around. Eating is a real chore. Dried and frozen foods are stored in plastic bags. To eat chicken soup, the astronauts cut a hole in one end of a bag and squeeze the soup into their mouths.
Generalization	Although all living things are made of cells, all cells are not the same. Some plant cells have a boxlike shape. Some even contain a green material called chlorophyll. When sunlight strikes chlorophyll, the cell can make food for the plant. Animal cells do not contain chlorophyll and are not box-shaped.

task (Montelongo and Hernández 2007). It links learning science content with learning to read and write expository texts. With this strategy, comprehension instruction is no longer an isolated teaching practice, but rather an integrated exercise in science and technology.

TEXT STRUCTURES IN SCIENCE

All texts have a structure. Within a text, paragraphs have a particular pattern of organization or text structure (Cook and Mayer 1988; Sutherland 2008). Paragraphs are comprised of a main idea and its supporting details. Facts, reasons, or examples can be used to explain the main idea. Some of the most common types of expository paragraphs in science texts are *problem–solution*, *compare–contrast*, *cause–effect*, and *generalization*. The main ideas and supporting details for different expository paragraphs require different strategies and new vocabulary to be understood and analyzed. Students must learn new vocabulary and practice reading various text structures if they are to become proficient readers and writers of informational science texts (Graesser 2007).

Using their own science textbooks, teachers can target vocabulary and select paragraphs to illustrate the text structure they choose to teach. These expository text structures are presented in Table 1.

GRAPHIC ORGANIZERS AND SIGNAL WORDS

Text structures can be represented graphically to convey the relationship between the main idea and its supporting details. Students use graphic organizers to depict, understand, and remember information from text. Graphic organizers can be used to analyze as well as generate text. Examples of graphic organizers are presented in Figures 1 and 2. The graphic organizer in Figure 1

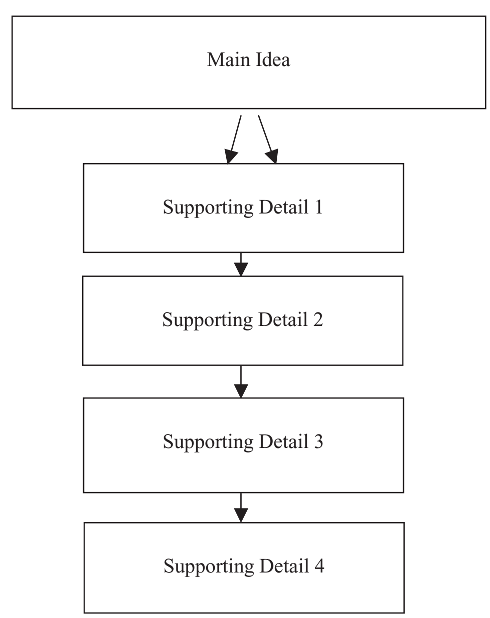


FIGURE 1 **Sample generalization graphic organizer.**

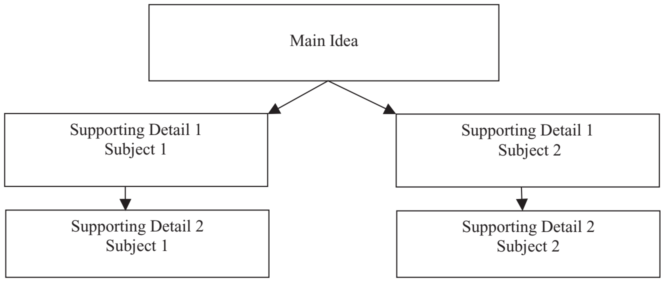


FIGURE 2 **Sample comparison–contrast graphic organizer.**

is for expository paragraphs that have a generalization text structure. The supporting details in this structure are intended to prove or explain the main idea. The graphic organizer in Figure 2 is for expository paragraphs with a comparison–contrast text structure. This graphic organizer is bifurcated to divide the supporting details for the initial subject from those of the subject being compared or contrasted.

Signal words cue the reader to the structure of a paragraph. For example, the words *because* and *consequently* signal a cause-and-effect paragraph. Words and phrases such as *similarly* and *on the other hand* signal a comparison–contrast paragraph. Noting these cues helps readers recognize the structure of a paragraph and, consequently, its intended purpose and meaning. Examples of signal words and phrases appear in Table 2.

Teachers provide practice with expository text structures, signal words, and graphic organizers. Students require many opportunities to practice while they acquire the skills of identifying new vocabulary, understanding text structures, locating the main ideas of a paragraph, and summarizing what they have read. This guided practice supports students as they internalize vocabulary and develop these comprehension processes.

THE MODIFIED SENTENCE-COMPLETION TASK

One way of providing students frequent practice with vocabulary, locating main ideas, and identifying expository text structures is to use the modified sentence-completion task. It is a more versatile form of the common fill-in-the-blanks activity found at every grade level (Montelongo and Hernández 2007). Although we recognize that fill-in-the-blank worksheets evoke memories of plodding through handouts, this activity has been met with enthusiasm by upper-elementary and middle school students. Its versatility derives from teachers having the power to determine the content of the activity in a familiar format.

The modified sentence-completion task begins with the teacher selecting a content-rich paragraph of four to six sentences taken from a science textbook. Then the teacher adds an equal number of extraneous sentences. The point is to guide students to read and identify the relevant sentences from the irrelevant ones. After the sentences have been scrambled on the worksheet, the teacher selects 10 to 12 vocabulary words and moves those words to a word bank, thus targeting them for learning.

After the students have completed the vocabulary fill-in-the-blanks, they abstract the hidden paragraph. They find the main-idea sentence and the supporting details and logically order these sentences to form a new paragraph. Students paste the ordered sentences onto a graphic organizer. As a final step, students use the abstracted paragraph as a scaffold to rewrite the paragraph in their own words. In short, students practice using new vocabulary words, locating main ideas, recognizing signal words, identifying different text structures, and writing expository text. Examples of the sentence-completion activity for an elementary science class and a middle school science class are presented in Appendix A and Appendix B.

The expository paragraph in Appendix A uses the generalization text structure in its discussion of gases and volume for fourth-grade students. The paragraph in Appendix B compares and contrasts the differences between scientific theories and scientific laws for middle school students.

TABLE 2 **Signal Words and Phrases for Science Expository Text Structures**

Generalization	Compare–Contrast	Cause–Effect	Problem–Solution
for example	like	because	problem
to illustrate	similarly	since	answer
for instance	on the other hand	consequently	solution
to begin with	however	thus	response

The theoretical basis for the modified sentence-completion task can be found in reading theories that suggest that reading comprehension results from the interaction between the author's organization of ideas and a reader's prior knowledge (e.g., Spivey 1990, 1997). Authors take students' prior knowledge into account when writing their texts. They provide their readers with the supporting details necessary to increase the strength and learnability of the main ideas. For their part, readers bring a pre-existing level of prior knowledge of the topic to the reading act. This prior knowledge consists of images, facts, opinions, and associations about the topic acquired from texts, experiences, and other sources of information stored in memory.

The degree to which a reader's prior knowledge facilitates or inhibits the comprehension of text is dependent on the fit between an author's organization and explanation of the expository material (Spivey 1997). Expository text that is consistent with the reader's pre-existing mental representations of the topic is more likely to be comprehended, assimilated, accommodated, and remembered than material that is not. Expository text that is inconsistent with a reader's prior knowledge is more likely to be misunderstood, learned poorly, and forgotten.

Teachers can do their share to ensure that their students develop the mental representations necessary to understand expository text. They can do this by teaching their students the different expository text structures, along with the new and difficult vocabulary introduced in unfamiliar text. They can also help students internalize the various text structures by scaffolding students' expository writing through the use of these text structures. Through constant practice, the modified sentence-completion task can be used to accomplish these goals.

TEXT STRUCTURES AND LEARNING

Internalizing text structures provides students with a framework for understanding new information. Recognizing text structures facilitates the learning of informational text because it enables the reader to form a mental picture of the information and to see the logical relationships advanced by the author (Ogle and Blachowicz 2001). Like chess masters who use structure to remember the positions of each piece on the chessboard, good readers employ text structures to help them learn and recall what they read (Taylor and Samuels 1983).

Variations of the modified sentence-completion tasks have been used to develop student awareness of text structures in science classes (Montelongo et al. 2006), the structures of arithmetic word problems (Montelongo, Hernández, and Herter 2009), and the structures involved in writing conclusions for science experiments (Berber-Jiménez et al 2008). Montelongo (2008) further suggests that this activity can also be used to frontload content area information for English language learners (ELLs).

The modified sentence-completion task is a versatile strategy that can be used with a word-processing program or a teacher-created Web site. Using technology, students can find the related sentences, logically order them, and rewrite the abstracted paragraph in their own words. Research studies reveal that K–12 students produce quantitatively more and qualitatively better writing when they are allowed to use computers than when they use paper and pencils (Goldberg et al. 2003). In our classroom experiences, we have found that students like using technology to complete the activities in the modified sentence-completion task.

THE MODIFIED SENTENCE-COMPLETION TASK WITH COMPUTER TECHNOLOGY

Effective science programs use technology to teach students. Teaching science by using technology is important for preparing students to be scientifically and technologically literate (California Department of Education 2004).

The use of computer technology gives students more options for completing the modified sentence-completion task than does a paper-and-pencil activity at each step in the process. With a word-processing program, students can use the dictionary or the thesaurus to check the meanings of the vocabulary words in the fill-in-the blank exercises. Students can consult an online encyclopedia to gain more information about the subjects discussed in the exercises. In abstracting the related sentences that make up the hidden paragraph, students can copy and paste the related sentences into a graphic organizer several times and read them over until they are satisfied with the sentences they have selected. The use of technology also makes it easier for students to arrange the sentences logically. They can experiment with different orders and arrangements. They may test different main-idea placements and try out various ordering schemes for their supporting details. After the students have logically ordered the sentences and are pleased with the results, they can proceed to write their own paragraphs. The steps for completing the modified sentence-completion activity on a word processor are presented in Appendix C.

An axiom from cognitive psychology literature asserts that comprehension precedes production. When students truly understand the meaning of text, they are able to generate several representations of it. Technology allows students the opportunity to generate a graphic organizer that reflects their own mental representation of the material if they are unhappy with the graphic organizer provided by the teacher. By allowing students to create their own organizers, teachers can foster a deeper understanding of the various text structures. As Norton and Wiburg (2003, 152) point out,

> Teachers who promote literacy development design instruction that presents students with representative models of how others have combined symbols and cognitive strategies into culturally recognized and valued organizational patterns to communicate. Teachers who promote literacy development recognize the importance of providing students equal opportunities to emulate this process, moving from their own experiences and interpretations to symbolized representations of their thoughts.

Students can use graphic organizers as scaffolds to write paragraphs in their own voices. The act of composing a new paragraph from the abstracted sentences may be seen as an instance of composing from sources (Spivey and King 1989). In the transition from being the reader to becoming the writer, two knowledge sources affect the final product. These are the immediate source text (the abstracted sentences) and the student's prior knowledge. Encouraging students to create their own paragraphs allows for the interaction between the immediate text and student knowledge. Spivey (1990, 257) asserts, "Both kinds of sources–the immediate texts and knowledge gained from prior experience–exert a powerful force on the way the writer organizes meaning, the selections that are made, and the elaborations and inventions that are generated."

The degree of creativity in constructing these new paragraphs may reflect students' prior knowledge. Students with little background are text-bound. They are not able to deviate much from the original text with regard to the content of the material. However, students with substantial prior knowledge about the topic can offer criticism of the author's arguments, add their own ideas, and follow where their curiosity leads as they rewrite their paragraphs in their own words.

Technology gives students many opportunities to change their original compositions. Students can edit and re-edit their compositions to reflect the interaction between the text and their prior knowledge. Teachers can help students edit their compositions by permitting them to use the dictionary, thesaurus, and encyclopedia provided by the word-processing program to create and support their arguments or to refute those provided by the author. Teachers can even encourage students to embellish their compositions through the use of a clip-art program or their own artwork and to enhance with pictures what they have conveyed with words, thus reinforcing student autonomy. This activity allows students to interact with text and modify it to reflect their intelligence, creativity, and enthusiasm for the information in the text.

THE MODIFIED SENTENCE-COMPLETION TASK ON AN INTERNET WEB PAGE

The modified sentence-completion task can be made even more versatile when it is placed on an Internet Web page. Taylor et al. (2002) suggest that effective practice engages students in active reading and writing. The use of the Internet allows the modified sentence-completion activity to be more interactive through the use of feedback. This can be done by providing students with corrective feedback on their choice of answers. A Web page can be designed to provide the students with corrective feedback for their choices in the fill-in-the-blanks task, their selections of the related sentences, and their logical orderings of sentences. It also provides students the self-regulation that Pressley et al. (2001) found in the classrooms of outstanding reading teachers.

As Pearson et al. (2005) have suggested, teachers need not be bystanders in the use of technology in classrooms. They can tailor their instruction by creating Web pages that include sentence-completion tasks in tandem with other educational resources, as in the sample Web site in Figure 3a–c. When the sentence-completion task is placed on an Internet Web page, student learning may be extended beyond the classroom walls. Students are afforded the freedom to expand their learning and to be creative. They are not locked into being consumers of knowledge but can also act as co-creators alongside the authors of the

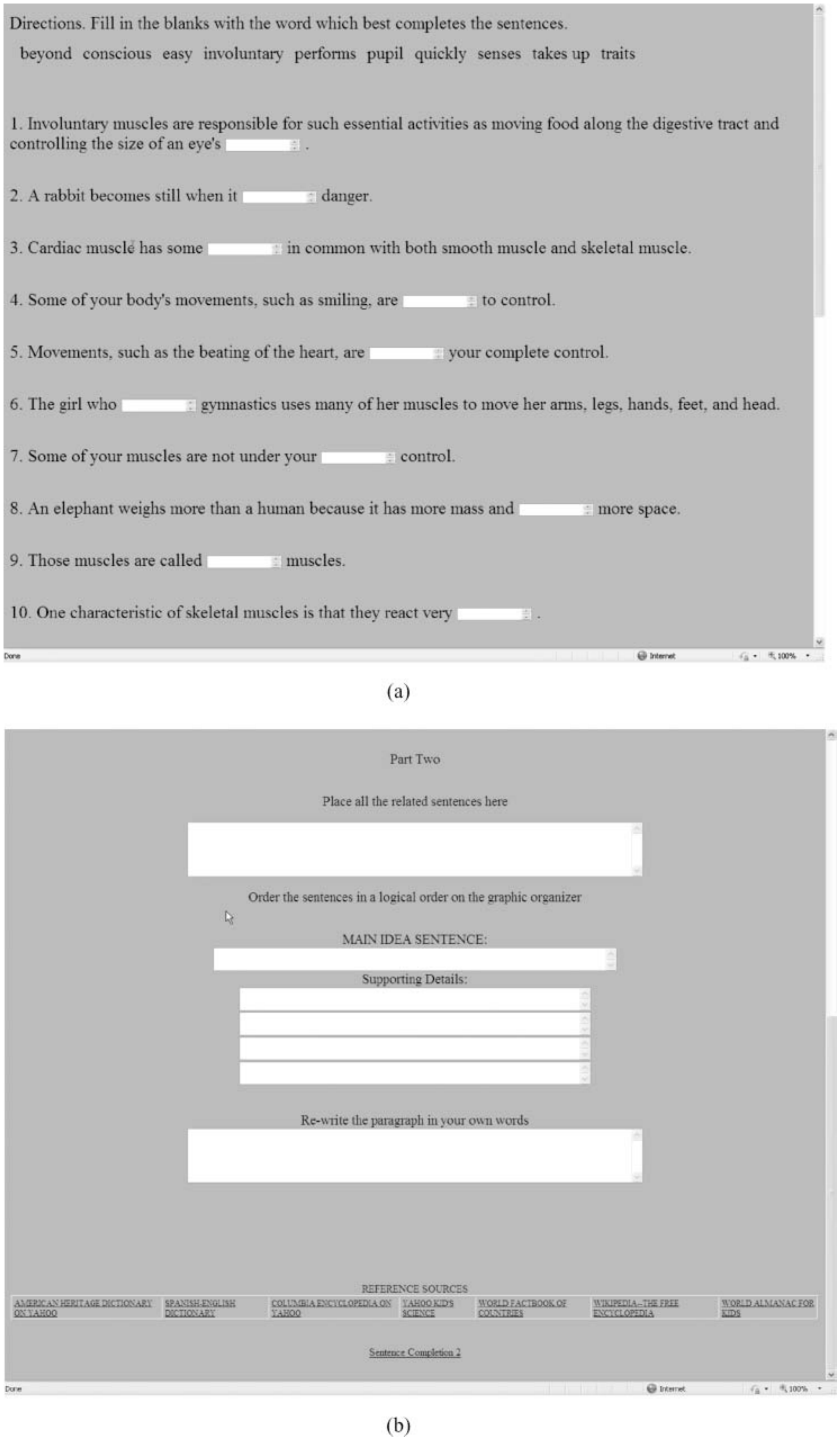
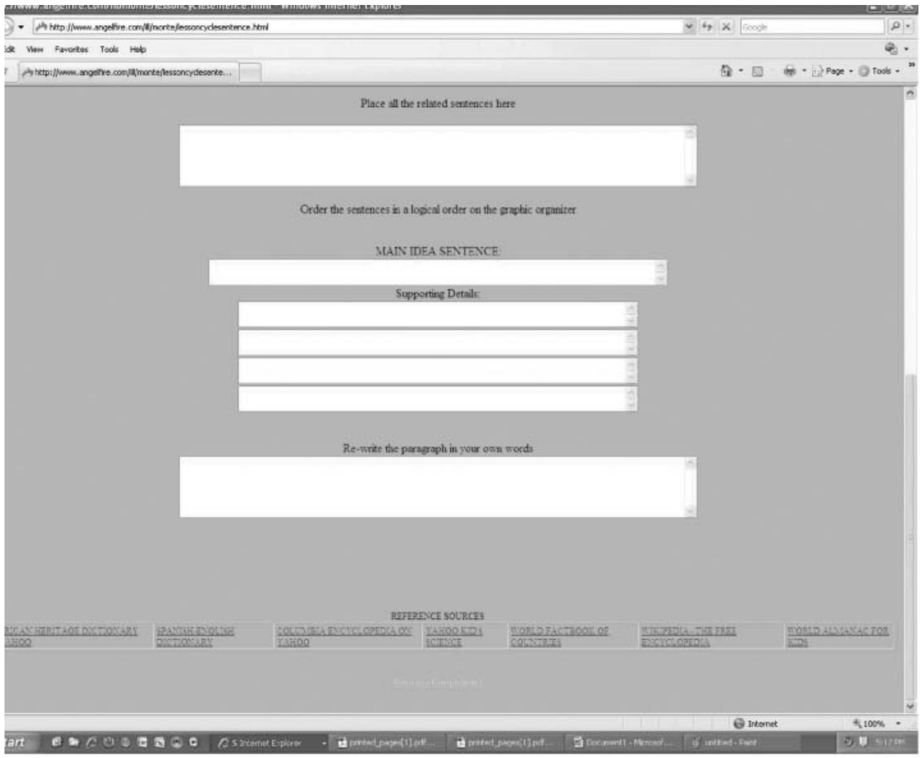


FIGURE 3 **Web site version of the modified sentence-completion task, Screens A–C.**



(c)

FIGURE 3 *(Continued)*

texts they are reading. They can consult infinitely more informational resources while working on a Web page than when working on a word processor. Students have access to countless online dictionaries, encyclopedias, science sites, country fact books, and almanacs, in addition to the infinite number of other sites on the Internet. Students can consult such Web sites to strengthen their understanding of the author's main ideas or to add to their knowledge of the science material. On the Internet, students can access science-related software, online sites, artwork, and music related to their topics that can strengthen their understanding. A teacher's Web page can also include Spanish-English dictionaries to help Spanish-speaking ELLs understand the text. The Web site depicted in Figure 3a–c may be accessed at http://www.angelfire.com/ill/monte/lessoncyclesentence.html.

CONCLUSION

The presentation of the exercises that comprise the modified sentence-completion task using technology propels students into 21st-century learning. Furthermore, technology obligates schools to encourage students to fully engage its potential in their own learning. The science classroom is ideally suited to the exploration of interaction between authors' ideas in written texts to the possibilities present in students' imaginations. Teaching and learning scientific knowledge and competence begin with the ability to read and write. This strategy teaches students to go beyond the boundaries of text while guiding and grounding their comprehension of it. For all the advantages of technology, reading and writing are the pathways to unlocking its potential.

As Pearson et al. (2005, 24) conclude, "We believe the time has come to take technology more seriously as a component of middle-school literacy curriculum and pedagogy." We suggest that the use of this strategy, enhanced by the power of technology, can support expository reading and writing across the entire K–12 science curriculum.

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APPENDIX A:
MODIFIED SENTENCE-COMPLETION TASK FOR A FOURTH-GRADE SCIENCE CLASS

Step 1: Complete the sentences with the appropriate vocabulary words.

crust	ecosystem	faster	gases	matter
plates	shape	solid	spread	unlike

1. Any waste product that damages an ______________ is called pollution.
2. Like atoms and molecules in liquids, the bits in ______________ are not arranged in any pattern.
3. All ______________ is made up of atoms and molecules.
4. This is because atoms and molecules in gases are moving much ______________ than those in liquids.
5. Earth's surface is not a single piece of rock, but is made up of many ______________.
6. These particles are ______________ very far apart.
7. Atoms and molecules in a ______________ stay close together and move back and forth in all directions but around one point.
8. A gas is matter that has no definite ______________ and takes up no definite amount of space.
9. Earth has three layers: the ______________, the mantle, and the core.
10. ______________ atoms and molecules in liquids, however, those in gases don't stay close together.

Correct answers:

1.	ecosystem	2.	gases	3.	matter	4.	faster
5.	plates	6.	spread	7.	solid	8.	shape
9.	crust	10.	Unlike				

Step 2: Find the related sentences of a hidden paragraph.

2. Like atoms and molecules in liquids, the bits in ______________ are not arranged in any pattern.
4. This is because atoms and molecules in gases are moving much ______________ than those in liquids.
6. These particles are ______________ very far apart.
8. A gas is matter that has no definite ______________ and takes up no definite amount of space.
10. ______________ atoms and molecules in liquids, however, those in gases don't stay close together.

Step 3: Find the main idea and arrange the sentences in a logical order using the graphic organizer.

DIRECTIONS: PASTE THE MAIN IDEA AND SUPPORTING DETAILS IN THE GRAPHIC ORGANIZER.

MAIN IDEA: A gas is matter that has no definite shape and takes up no definite amount of space.

SUPPORTING DETAIL: Like atoms and molecules in liquids, the bits in gases are not arranged in any pattern.

SUPPORTING DETAIL: Unlike atoms and molecules in liquids, however, those in gases don't stay close

SUPPORTING DETAIL: These particles are spread very far apart.

SUPPORTING DETAIL: This is because atoms and molecules in gases are moving much faster than those in liquids.

Step 4. Write a paragraph using the graphic organizer as an outline.

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APPENDIX B:
MODIFIED SENTENCE-COMPLETION TASK FOR A SEVENTH-GRADE SCIENCE CLASS

Step 1: Complete the sentences with the appropriate vocabulary words.

applied	chemistry	hypothesis	knowledge	laws	method
papers	predict	results	scientific	technology	theory

1. Scientific ________________ only tell what happens, not why something happens.

2. One way scientists communicate with other scientists is by writing scientific ________________.

3. A ________________ is a unifying explanation for a broad range of hypotheses and observations that have been supported by testing.

4. Theories can be changed or replaced as new observations are made or as new ________________ are tested.

5. The scientific ________________ is the series of steps that scientists use to answer questions and solve problems.

6. The goal of science is to gain ________________ about the natural world.

7. The goal of ________________ is to apply scientific understanding to solve problems.

8. A scientific law is a summary of many experimental ________________.

9. Theories not only explain an observation, but also ________________ what will happen in the future.

10. Technology is sometimes known as ________________ science.

11. ________________ involves the study of all forms of matter and how they interact.

12. There are differences between ________________ theories and scientific laws.

Step 2: Find the related sentences:

1. Scientific laws only tell what happens, not why something happens.
3. A theory is a unifying explanation for a broad range of hypotheses and observations that have been supported by testing.
4. Theories can be changed or replaced as new observations are made or as new hypotheses are tested.
8. A scientific law is a summary of many experimental results.
9. Theories not only explain an observation, but also predict what will happen in the future.
12. There are differences between scientific theories and scientific laws.

Step 3: Find the related sentences. Paste them onto the graphic organizer.

There are differences between scientific theories and scientific laws.

A theory is a unifying explanation for a broad range of hypotheses and observations that have been supported by testing.

Theories not only explain an observation, but also predict what will happen in the future.

Theories can be changed or replaced as new observations are made or as new hypotheses are tested.

A scientific law is a summary of many experimental results.

Scientific laws only tell what happens, not why something happens.

Step 4. Write a paragraph using the graphic organizer as an outline.

APPENDIX C:
MODIFIED SENTENCE-COMPLETION TASK USING A WORD PROCESSOR

Step 1: Fill-in the blanks with the appropriate words.

Directions: Complete the sentences with the correct vocabulary word.

charge	hypothesis	inference	matter	microscope
negatively	particles	positively	static electricity	variables

When an object has more ________________ with a negative charge than particles with a positive charge, it is negatively charged.

The buildup of charges in one place is called ________________.

It will attract a ________________ charged object and repel a negatively charged object.

A ________________ is a testable explanation of observations.

To observe very small details, you might use a ________________.

A scientist controls ________________ to know what caused the results.

Every particle in ________________ can have a positive or negative charge.

It will attract a ________________ charged object and repel a positively charged object.

An ________________ is a conclusion based on observations and what you already know.

If an object has more particles with a positive ________________, it is positively charged.

Step 2: Find the related sentences of a hidden paragraph.

When an object has more <u>particles</u> with a negative charge than particles with a positive charge, it is negatively charged.
It will attract a <u>positively</u> charged object and repel a negatively charged object.
Every particle in <u>matter</u> can have a positive or negative charge.
It will attract a <u>negatively</u> charged object and repel a positively charged object.
If an object has more particles with a positive <u>charge</u>, it is positively charged.

Step 3: Find the main idea and arrange the sentences in a logical order using the graphic organizer or create a graphic organizer of your own.

Main Idea Sentence
Every particle in matter can have a positive or negative charge.

Detail 1
If an object has more particles with a positive charge, it is positively charged.

Detail 2
It will attract a negatively charged object and repel a positively charged object.

Detail 3
When an object has more particles with a negative charge than particles with a positive charge, it is negatively charged.

Detail 4
It will attract a positively charged object and repel a negatively charged object.

Step 4. Write a paragraph in your own words using the graphic organizer as an outline on another sheet of paper. Use the dictionary, a thesaurus, or other reference works to make this composition your own.

Step 5. Include fonts, clip art, your own drawings and/or pictures and photographs from the Internet for your composition.