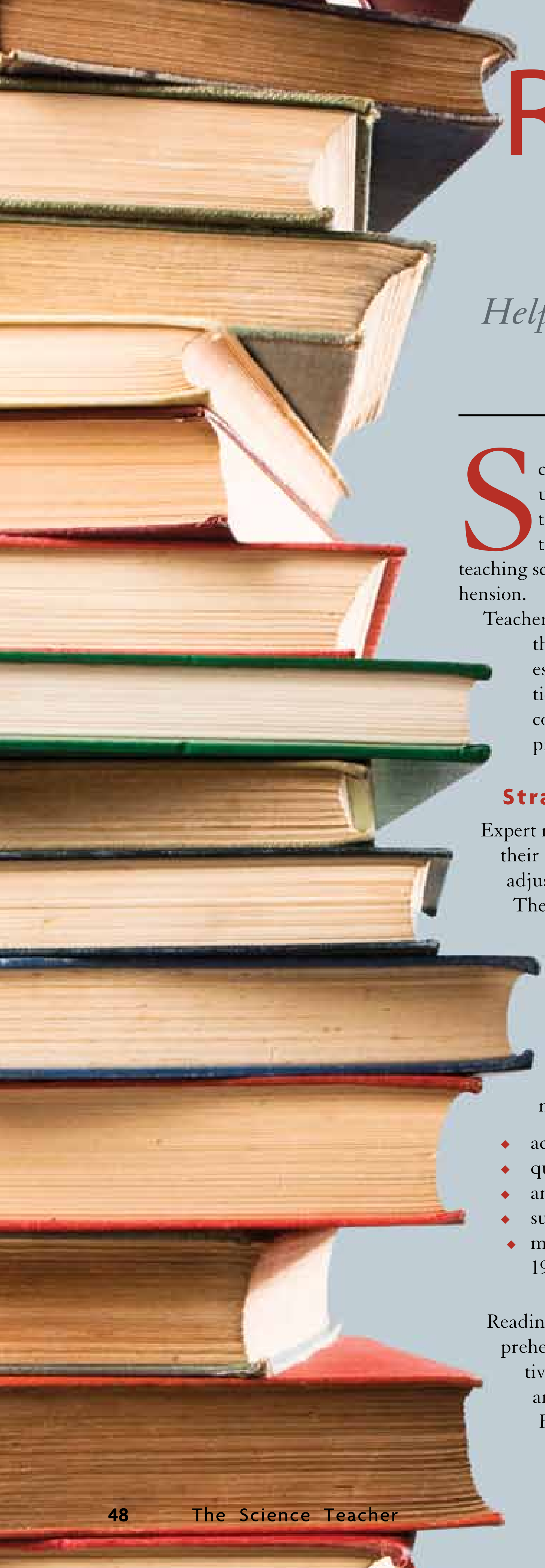


Reading to Learn

Helping students comprehend readings in science class

Phillip Herman and Peter Wardrip

Science teachers expect high school students to know how to read, understand, and learn from texts at the core of the curriculum. But though students learn to read in grade school, many don't know how to "read to learn" science. And science teachers are often too busy teaching science to actively help students increase their science reading comprehension.

Teachers need effective tools to help students learn more science and develop the critical reading-to-learn skills that literacy research identifies as essential for academic success (Biancarosa and Snow 2006). This article provides three practical approaches to increase reading-to-learn competencies and student science achievement. These approaches also provide valuable information about student understanding of content.

Strategies of expert readers

Expert readers interact with text differently than novice readers: They know their purpose for reading, continually monitor their understanding, and adjust their reading effort to the complexity of the text (Pressley 2000). These readers realize that reading is a meaning-making task (Scardamalia and Bereiter 1986; Pressley and Gaskins 2006) and can relate what they read to prior knowledge. They note discrepancies in their understanding—both as they read and, later, when they internally summarize the reading—and choose new strategies to overcome these roadblocks, whereas struggling readers simply ignore roadblocks and push on (Clay 1991; Pressley 2000).

Expert readers understand the cognitive, metacognitive, and motivational processes of reading to learn:

- activating background knowledge,
- questioning to construct meaning,
- answering questions,
- summarizing, and
- monitoring comprehension within a self-regulating system (Yore et al. 1997).

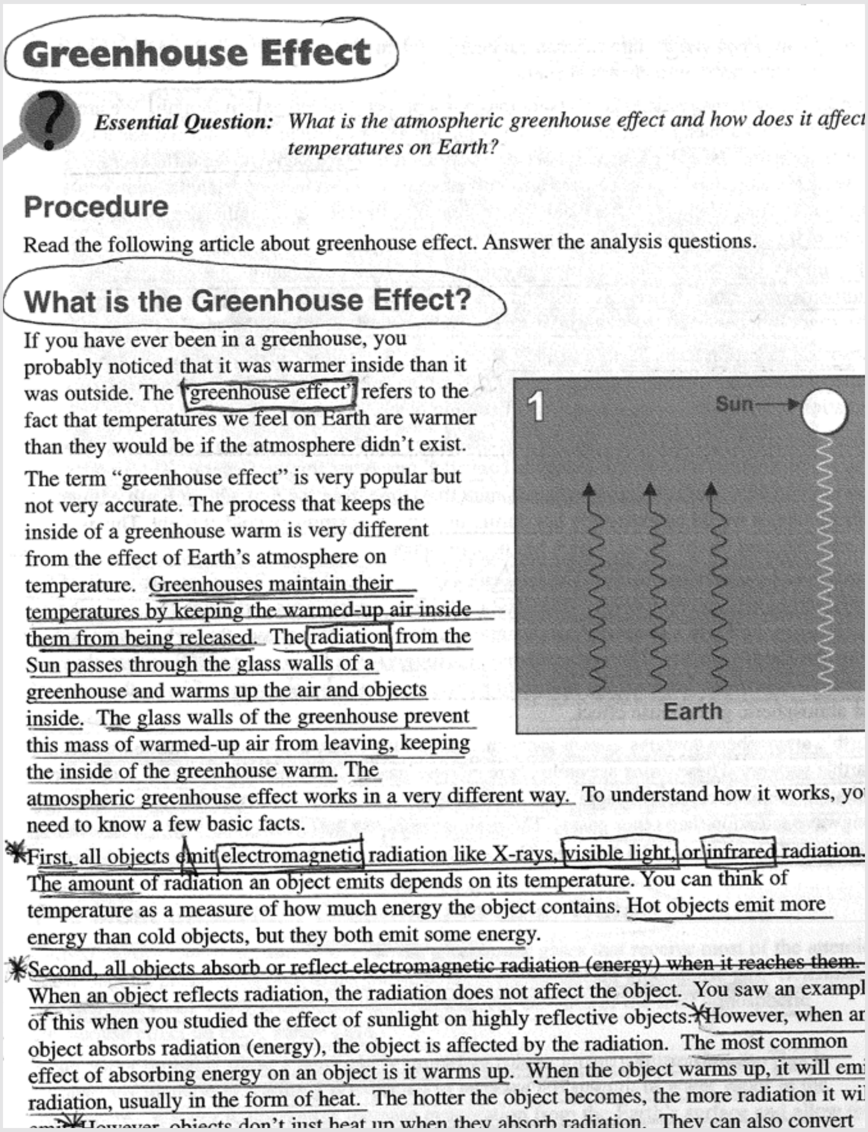
Reading-to-learn strategies can help students increase their reading comprehension (Anderson 1992; Collins 1991). Through practice, collaborative analysis, and discussion with peers, students can better internalize and ultimately take ownership of these strategies (Pressley et al. 1992; Biancarosa and Snow 2006). They can learn to identify the general structure of text; critical elements such as main ideas, supporting ideas, arguments, and evidence; and signposts such as transitions, comparisons, and contrasts (Gomez, Herman, and Gomez 2007).

These strategies can also help students learn to reflect on, deconstruct, organize, and analyze text so that it can be critiqued for understanding and communication (Gomez and Gomez 2006; Gomez, Herman, and Gomez 2007). They should know how to integrate new and prior knowledge about a topic into a summary of the reading, helping them communicate their understanding of what they have read (Kintsch 1998).

In the next sections, we describe three tools to support reading to learn in science classrooms. The first two, annotation and double-entry journals, are student strategies. The third approach encourages teachers to more clearly articulate what students should learn from a particular text and to fit the other two tools into their ongoing instruction planning.

FIGURE 1

Sample student annotation (Edelson 2005).



Greenhouse Effect

Essential Question: *What is the atmospheric greenhouse effect and how does it affect temperatures on Earth?*

Procedure

Read the following article about greenhouse effect. Answer the analysis questions.

What is the Greenhouse Effect?

If you have ever been in a greenhouse, you probably noticed that it was warmer inside than it was outside. The "greenhouse effect" refers to the fact that temperatures we feel on Earth are warmer than they would be if the atmosphere didn't exist.

The term "greenhouse effect" is very popular but not very accurate. The process that keeps the inside of a greenhouse warm is very different from the effect of Earth's atmosphere on temperature. Greenhouses maintain their temperatures by keeping the warmed-up air inside them from being released. The radiation from the Sun passes through the glass walls of a greenhouse and warms up the air and objects inside. The glass walls of the greenhouse prevent this mass of warmed-up air from leaving, keeping the inside of the greenhouse warm. The atmospheric greenhouse effect works in a very different way. To understand how it works, yo need to know a few basic facts.

First, all objects emit electromagnetic radiation like X-rays, visible light, or infrared radiation. The amount of radiation an object emits depends on its temperature. You can think of temperature as a measure of how much energy the object contains. Hot objects emit more energy than cold objects, but they both emit some energy.

Second, all objects absorb or reflect electromagnetic radiation (energy) when it reaches them. When an object reflects radiation, the radiation does not affect the object. You saw an exampl of this when you studied the effect of sunlight on highly reflective objects. However, when ar object absorbs radiation (energy), the object is affected by the radiation. The most common effect of absorbing energy on an object is it warms up. When the object warms up, it will emi radiation, usually in the form of heat. The hotter the object becomes, the more radiation it wi However objects don't just heat up when they absorb radiation. They can also convert

Annotation

Annotation is a form of content analysis in which students mark up key elements of the text such as main ideas, argument structure, connections between visuals and narrative text, and new vocabulary. (**Note:** Supply photocopies if students aren't allowed to mark up texts.) Text annotation helps students understand the author's message as they construct mental models of the text. Students learn how to identify important information and disregard irrelevant information. They typically annotate one or more of the following:

- difficult or new science vocabulary words and in-text definitions;
- difficult nonscience vocabulary words;
- main ideas or arguments and related supporting ideas or evidence;
- headings, transitional words, and other signposts;
- inferences; and
- conclusions.

As students identify the main idea and search for supporting ideas, they begin to understand the structure of the text elements. Teachers should model this annotation process until students can annotate text independently, indicating their levels of understanding.

Figure 1 is an example of an annotation from an article on global warming. Students read the photocopied passage on climate change; circled the heading; double-underlined each paragraph's main ideas; single-underlined the supporting details; and drew boxes to indicate key terms or unknown vocabulary. Typically, students write "DEF" near the definitions for unfamiliar terms; this encourages the reader to look for contextual clues to make sense of new words.

In our experiences, annotating

- gives students an entry point into the reading and specific tasks to accomplish, such as circling headings and boxing key vocabulary;
- allows students to reflect on the purpose of the reading and which sentences support that purpose;
- indicates how well students understand the passage; and
- suggests questions the teacher should ask students.

Double-entry journals

A double-entry journal (DEJ), also called a *t-chart,* is a reader-response log with two or more columns that provides a structure for students to monitor and document their understanding of science texts. Students fill out two (or more) columns in a structured format. Completing a DEJ gives students a chance to actively read and reflect on what they have read. There are a variety of DEJ structures, allowing teachers to focus student reading on an important idea or skill unique to a text (e.g., vocabulary, main ideas with supporting ideas, prior knowledge).

Figure 2 is an example of what we call a triple-entry journal (TEJ) with three columns. It demonstrates the flexibility of this approach. Students pictorially represent three trials in an experiment and explain their representations of each condition. In other versions, the columns can represent arguments and evidence, main and supporting ideas, vocabulary items and students' understanding of the items, and so on.

Constructing DEJs, similarly to using annotations, can serve several goals in a science classroom. For example, it can encourage students to reflect on the meaning of a reading and articulate their understanding through different representations. Completed DEJs provide teachers with evidence of student thinking and suggestions on where they should try to further student understanding.

Students who productively use annotation and DEJ (or TEJ) strategies demonstrate better understanding on related assessments (Herman et al. 2008; Herman et al. 2010).

Be explicit

We ask teachers we work with to analyze their reading assignments in terms of big ideas and ongoing science learning goals. Teachers explicitly tell students what is likely to be difficult in a particular reading, such as vocabulary, misconceptions, and complicated inferences. They discuss with students what is relevant to reading-to-learn goals and how the reading fits into ongoing instruction.

This attention to the function of specific readings has significant implications. For example, the reading that appears first in a textbook or chapter shouldn't necessarily be read first. Students might perform a hands-on lab, read, and then highlight something explored in the lab in their DEJs. Teachers can be strategic in their reading assignments and support for reading strategies. For example, to prepare for a class debate, students may only need to read and annotate the first and last paragraphs of a reading.

As teachers learn to be more explicit about the purposes of reading in their instructional flow, they become more adept at supporting learners who struggle to integrate the readings with prior knowledge and ongoing instruction. Being more explicit about how a reading fits into science learning can help teachers improve their overall science instruction as they clarify how each element of instruction (reading, lab, activity, discussion) helps students learn and integrate new knowledge.

Conclusion

Teachers need a repertoire of supports that are effective and practical in classrooms. The evidence-based approaches described in this article can help science teachers support students' reading-to-learn competencies. These competencies are important for higher levels of science achievement. Being scientifically literate includes an ability to learn from science texts in a variety of media such as textbooks, research reports, newspapers, and magazines. By actively attending to, planning for, and supporting reading in science classrooms, teachers help students develop a deep understanding of science phenomena and the role of science in their lives. ■

Phillip Herman (pherman@pitt.edu) *is the director of research for the Center for Urban Education and visiting assistant professor of Learning Sciences and Policy, and Peter Wardrip* (psw9@pitt.edu) *is a doctoral candidate in Learning Sciences and Policy, both at the University of Pittsburgh in Pennsylvania.*

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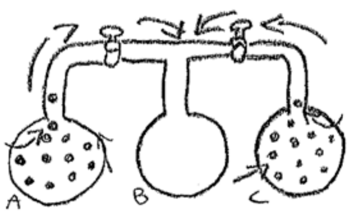
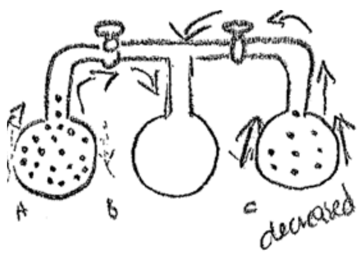
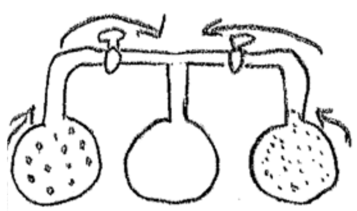
FIGURE 2

Example of a student triple-entry journal.

Directions: In the second column, create a diagram of the initial setup of the three bulbs. Use arrows to show the movement of molecules. In the third column, write a description of how equilibrium was achieved.

Trial	Diagram	Description
Trial 1		For trial one, A and C have the same initial concentration. When B is at 0 in the final results, the amount for A and B decreased, showing the equilibrium decreased, but all were equal.
Trial 2		The same effect took place. A had a higher concentration than C, but both decreased in the final concentration.
Trial 3		For trial 3, A had a lower concentration than C. Like the other trials, the final concentration had the same amount, showing that the equilibrium does in fact move.

(**Note:** Handwritten student notes were typeset for clarity.)

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