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Annotating to Support Learning in the Content Areas: Teaching and Learning Science

By using approaches like annotation, students learn to read more effectively and will learn content area topics more deeply.

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Today's teachers, perhaps more than ever before, must prepare U.S. students for the global marketplace. To be effective in the 21st century, students must compete in an environment in which they must be able to read expertly, think critically, and communicate effectively through writing and speaking (Levy & Murnane, 2004). As Conley (2008) has stated,

> To successfully operate in college and in the workplace, now and in the future, adolescents will need to master cognitive strategies for reading, writing, and thinking in complex situations where texts, skills, or requisite knowledge are fluid and not always clearly understood. (p. 85)

The presence or lack of literacy skills will make a tremendous difference in a student's ability to understand political, social, and scientific issues. Likewise, a student's literacy skill level will have an impact on employability and life chances.

Our focus is in exploring ways to remedy students' failure to acquire reading-to-learn skills. During the early primary years, schools expect that children will learn to read. That is, children will learn to decode and comprehend a relatively narrow range of texts. From the intermediate grades forward, schools and teachers have a different expectation. The expectation is that readers will have the requisite skills necessary for reading-to-learn (Yore, Shymansky, Henriques, Chidsey, & Lewis, 1997). With decoding and other basic skills in place, most learners use reading as the most fundamental tool in learning from then on. From early adolescence throughout the life course successful learners apply reading-to-learn skills to newly encountered text in school, in the workplace, on the Internet—in short, everywhere—to learn (Gomez & Gomez, 2007).

How can we help students become expert readers in the content areas? What can we do to help students learn to pay more attention to how and what information is presented? In this article, we describe how classroom teachers can use a strategic literacy approach called annotation to help students become better readers of content area materials, increase their reading

scores (Gomez & Gomez, 2007; Sherer et al., 2008), and improve their content understanding. Our multiyear intervention, the Adolescent Literacy Support Project, includes the establishment of strategic literacy approaches and instructional routines that support this work in middle and high school classrooms, ongoing professional development support for teachers, and iterative refinement of instructional materials to support teaching and learning with text. For the work described here, a strategic literacy approach refers to the use of instructional routines and literacy strategies to support students' meaning making with text.

Reading and writing should be essential components of any classroom. It is important to prepare students to read and write more effectively so they can gain more information from their reading materials. Annotation is a reading strategy that students can, and do, adopt and use in subjects such as mathematics, social studies, literature, and science. Annotation is a structured way to mark up text so it is more manageable. Students use annotation to highlight important information like main ideas (argument or claim), supporting ideas (evidence), key content vocabulary words, definitions, and transitions within the text. For example, students may be asked draw a rectangle around important vocabulary words or to double-underline main ideas and single-underline supporting ideas that are present within their assigned reading.

Annotation is a strategy that teachers can introduce to their students as a means to teach content. Students can then use it in their content classes or with other complex text they may come across. When students annotate they can better see how the author structures an argument in the text. The best benefit of annotation, however, is that because students are focusing closely on the structure and content of the text, they become more active and engaged readers.

Annotation is one of several cognitive literacy strategies (Conley, 2008; Pressley, 2006) that are used to help students see structure, analyze ideas, derive meaning, and communicate understandings. When students annotate texts they are taking one of several steps in our intervention design to recognize the ways authors make arguments and provide supporting evidence or details for those arguments. Annotation as a cognitive literacy approach helps students recognize how words and phrases and their definitions can be embedded skillfully in text yet in ways that (for struggling readers at least) are difficult to recognize, extract, and use to make meaning. It helps students begin to analytically approach texts by looking for structures and patterns that are used to convey information. In our work we also use other cognitive literacy approaches (e.g., double-entry journals and summary writing), to extend this cognitive activity (Gomez, Gomez, & Herman, under review; Sherer et al., 2008).

Armbruster and Anderson (1988) have argued for the importance of making texts more considerate for readers. Specifically, they stated that many texts are difficult for readers to navigate. They may lack useful headings and definitions or the headings and definitions may be unclear, or be embedded in ways that are not easily recognizable. Vocabulary and transitions that carry a great deal of content meaning may be present but aren't apparent.

We developed our approach to annotation based on our recognition of the need to make texts more considerate. We were conceptually guided by the reading-to-learn framework and cognitive approaches to supporting reading. These approaches recognize that expert readers have, and apply, a toolkit of strategies during the reading process (Pressley, 2000; Pressley & Wharton-McDonald, 1997); that meaning is constructed during reading and is an interactive process between learner, text, and context; and that expert readers monitor and self-regulate their learning with text. Less expert readers lack these strategies and often fail to gain information from text.

The overarching goal of the reading-to-learn framework is to apprentice learners into the culture of schooling and into the disciplinary community of practice. The framework, which advocates explicit instruction particularly around strategies, places an emphasis on two equally important issues for underprepared readers. First, students must understand that they *can* approach text to gain information and second, they must know *how* to approach text to comprehend its message.

By the time students reach high school, they often lack strategies to tackle their subject area reading materials. Although strategic reading skill development may be supported in English and reading

classes, often, less attention is given to the demands of reading nonnarrative or nonliterature-based text. Consequently, students grapple with reading in other subject areas, such as science, where reading is primarily expository, replete with charts, graphs, and other representations embedded in the text. In these other content area classes the ability to read is assumed and teachers' focus is, thus, on the content. Asking students to read and understand science content without providing and encouraging the use of strategic reading approaches like annotation, can and frequently does result in poor understanding of content material, limited class discussion (because students don't understand the material), and lack of interest in science.

How Will My Students Benefit From Annotation?

Students often assume that scientists do exciting experiments and field work but rarely read or write. In fact, scientists read prior research related to their experiments, write laboratory reports, develop content for popular and scholarly journals, and must be able to share their experiences with other colleagues. While reading, scientists, like other expert readers, often make jottings and other marginalia in books and articles. These jottings are ways of reinforcing ideas and they serve as reminders for the reader about things that are in question, words that are unknown, and the structure of an author's argument. Annotation can be a particularly useful strategy to use in science classes to encourage students to focus their attention on science content.

Annotation helps students visualize as they read, which in turn makes it easier for students to understand the content and become involved and engaged with the text. The act of annotating makes it difficult for readers to just skim through text without focusing on the important aspects and content within the text. Annotation shows critical information for quick reference by students. Because of this, annotations can be used as study guides for exams. If students annotate and use their annotations as references they may do better on exams and standardized tests because they are more engaged in the content.

As students begin to see annotation helping them in their science classes they will use it in other classes, as well. By using annotation, students begin to build a reading style that will help them with future reading. When they are able to deconstruct and evaluate the texts they read, students prepare for more advanced readings assigned in later grades, in college, and at work.

If students can't read, they can't learn from the text presented to them. Annotation not only helps students to read and retain information, but it may also help them to eventually read faster and more accurately because they will learn how to identify the most essential information (Sherer et al., 2008). In the next few sections, we'll describe how, and when, to use annotation and offer examples of its use in science classrooms. We use the following hypothetical example to illustrate how you might use this strategic literacy approach to help students become better readers of science text and gain a better understanding of the science content.

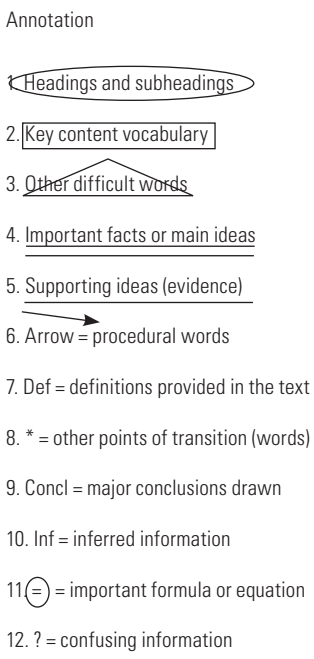
By following Ms. Granger, a ninth-grade Environmental Science teacher, through her implementation of annotation you will see how to explain annotation to your students, how to use annotation in the classroom, and how to avoid any possible problems that may arise during the process.

An Example of Annotation in the Classroom

On the first day of school, Ms. Granger explains to her class that they will be using annotation throughout the year. In her professional development meetings and in conversations with colleagues she has learned that it is important to make an early connection between science learning and the reading and writing that must be engaged in to support such learning. Ms. Granger tells students that annotation will help them to read better and to understand what they read. She doesn't go into any more detail but tells her students to expect an annotation activity later in the week. On the fourth day of school Ms. Granger shows her class a poster she has created with all of the annotation steps (see Figure 1). Ms. Granger also gives each student a copy of these steps and asks them to tape them to the cover of their science notebooks.

In this class period, Ms. Granger begins by reiterating the overall goals of annotation and explains how

Figure 1 Annotation Poster and Handout



the students will benefit from using it. Ms. Granger asks if students have ever read a paragraph and, at the end, not had a clue what they just read. She explains that students will be able to understand more of what they read by using annotation. She tells her class that annotation will help them to learn science and will help them to become better readers, which will prepare them for tests, college, and their future jobs.

Ms. Granger continues by describing each annotation step and explains how students annotate. She explains that sometimes students will only use some of the annotation steps. For example, a vocabulary annotation may be the most appropriate activity if the text has a large amount of important vocabulary words. Likewise, a reading may have many transitions as the author sets up and elaborates an argument. In that case, students may primarily circle headings, subheadings, and transitions to understand the structure and content of the article.

For this first lesson in learning annotation, Ms. Granger asks students what they think each step means before offering the ideal explanation. Following is a summary of the descriptions Ms. Granger gave her students about each of the steps:

1. Put a circle around headings and subheadings—Headings and subheadings usually symbolize a major point of transition. The headings and subheadings foreshadow what the next section is going to be about and show when the topic might be changing. Headings and subheadings should be circled.
2. Put a rectangle around key content vocabulary—Key content vocabulary is essential to understanding the content of the reading. Often these words may be bolded or italicized, but not always. These words should have a box drawn around them. Ms. Granger says that she will often give these vocabulary words to the students ahead of time, so they know they are important.
3. Put a triangle around other difficult or confusing words. These words are up to the individual student to choose and there is no right or wrong answer. Ms. Granger encourages her students to triangle as many words as necessary. *Note to teachers: Sometimes students don't know a word when they see it written but will know it when they hear it. Also, some words may have multiple meanings, which can be confusing (e.g., mass—unified body of matter in science or a Catholic church ceremony) This is why it's important to talk about other difficult and confusing words, as well as vocabulary words.*
4. Use a double-underline for main ideas (claims) or important facts—The main idea is the most important concept from a particular section of a text. It may be a single sentence, part of a sentence, or a combination of two or more sentences. The main idea will tell you what the rest of the paragraph or section is about. The main ideas may often relate to headings and subheadings that have been circled. *Note to teachers: It is up to you to decide how you want students to find main ideas. Some teachers will ask for one main idea per paragraph, while others ask for one or two for each section. It is also best to ask students to double-underline one complete sentence in the beginning. As students advance you can ask them to find multiple phrases or sentences that make up the main idea. In some kinds of science text (e.g.,*

physics) it is extremely difficult to find main ideas. In these instances it may be better to ask students to find important facts instead.

5. Use a single-underline for supporting ideas (evidence)—Supporting ideas should be single-underlined. Supporting ideas back up the main idea and provide more information about the main idea. *Note to teachers: Typically teachers will ask for a certain number of supporting ideas for each main idea (e.g., two or three).*
6. Draw an arrow next to procedural words—A procedural word is any word that gives direction and asks the reader to complete a task (e.g., write, measure, pour, draw, create). Procedural words are typically found within laboratory or activity instructions. By pointing out procedural words, students will know when they need to do something. An arrow should be drawn next to or above any of these words.
7. Write *def* next to definitions within the text—Often in science textbooks, definitions for vocabulary words are provided within the text either preceding or following the word. These definitions should be marked by writing *def* in the margin or space next to or above the definition. Definitions may also be embedded in the text for other difficult words that are not bolded or part of the key content vocabulary for that lesson.
8. Put an asterisk next to transition words or phrases within the text—Similar to headings and subheadings, transitions note a change is occurring. Transitions can be words (e.g., *however*, *first*) or they can be phrases (e.g., *on the other hand*, *in 1944*). These transitions are signals indicating that something is about to change, like the subject, date, or condition. An asterisk should be drawn next to transitions. *Note to teachers: Although you may easily recognize transitions, your students probably will not. Often students get confused about what they have read because they missed an important transition.*
9. Write *concl* next to any major conclusions—Conclusions are usually found at the end of a paragraph, section, or reading. They often summarize a large portion of preceding text. Not every text will have conclusions. *Concl* should be written next to or above any conclusions in the text.
10. Write *inf* next to inferred information—An inference is part of the text that assumes the reader already knows something or has already learned about a specific topic. When an inference appears in the text, *inf* should be written in the margin or space next to or above it. *Note to teachers: Students will struggle with this step. Keep in mind that you may have to point these out to students, particularly in the beginning.*
11. Put an equal sign with a circle around it next to important formulas or equations—All important equations or formulas should be labeled this way to help students to easily find information when answering questions or solving problems.
12. Put a question mark next to confusing information—A question mark should be drawn in the margin or space next to any sentence or paragraph that is confusing or unclear. A question mark can also be placed anywhere there is a question about the text. *Note to teachers: Encourage students to do this every time they read. You can then see where students are struggling and easily address questions.*

After describing each of the annotation steps, Ms. Granger hands out copies of the first reading assignment, on the greenhouse effect. Ms. Granger starts by probing students' background knowledge. She asks whether they have heard of the greenhouse effect and what they think it is. After students share their ideas (some of which are more accurate than others), Mrs. Granger asks students to read the text. Then, Ms. Granger explains that for this first lesson she and the students will use many, but not all, of the annotation steps. She also refers the students to an annotation poster on the classroom wall. The poster will remind students about the specific annotation steps they will use for each lesson. Ms. Granger informs the students that they will gradually learn how to apply all of the

steps throughout the school year. She also explains that not all of the steps are appropriate or can be found in the reading about the greenhouse effect.

Ms. Granger begins by asking the students to focus on the first step, circling headings and subheadings. She asks for a volunteer to point out the first heading. After the class agrees on the heading, Ms. Granger asks each student to circle the heading on their copy. Ms. Granger also circles the heading on her copy, which is displayed using an overhead projector. Ms. Granger asks for a second and third heading and asks students to circle these, as well. Ms. Granger explains that each of the headings explains what the sections following them are about.

After all headings and subheadings are circled Ms. Granger moves on to the second step, key content vocabulary words. She asks students to shout out the vocabulary words as they find them. As students say the words out loud Ms. Granger writes the words on the dry-erase board, boxes them on the overhead copy, and asks students to put a box around each word on their copy. She also gives a brief explanation of each of the words, but says they will be doing an activity later to further understand these words. After finding all vocabulary words, Ms. Granger asks the students for other words they don't understand. At first none of the students have any words to share. Ms. Granger gives a few examples (e.g., *impact*, *perhaps*, *emitting*) and has students put triangles around these words. She then asks students for more examples of difficult words. Ms. Granger also asks her students to keep a glossary of words in the back of their notebooks. Students are responsible for writing the definitions of words for homework, based on their understanding gleaned from the class discussion, the context of the reading, and if necessary, the dictionary.

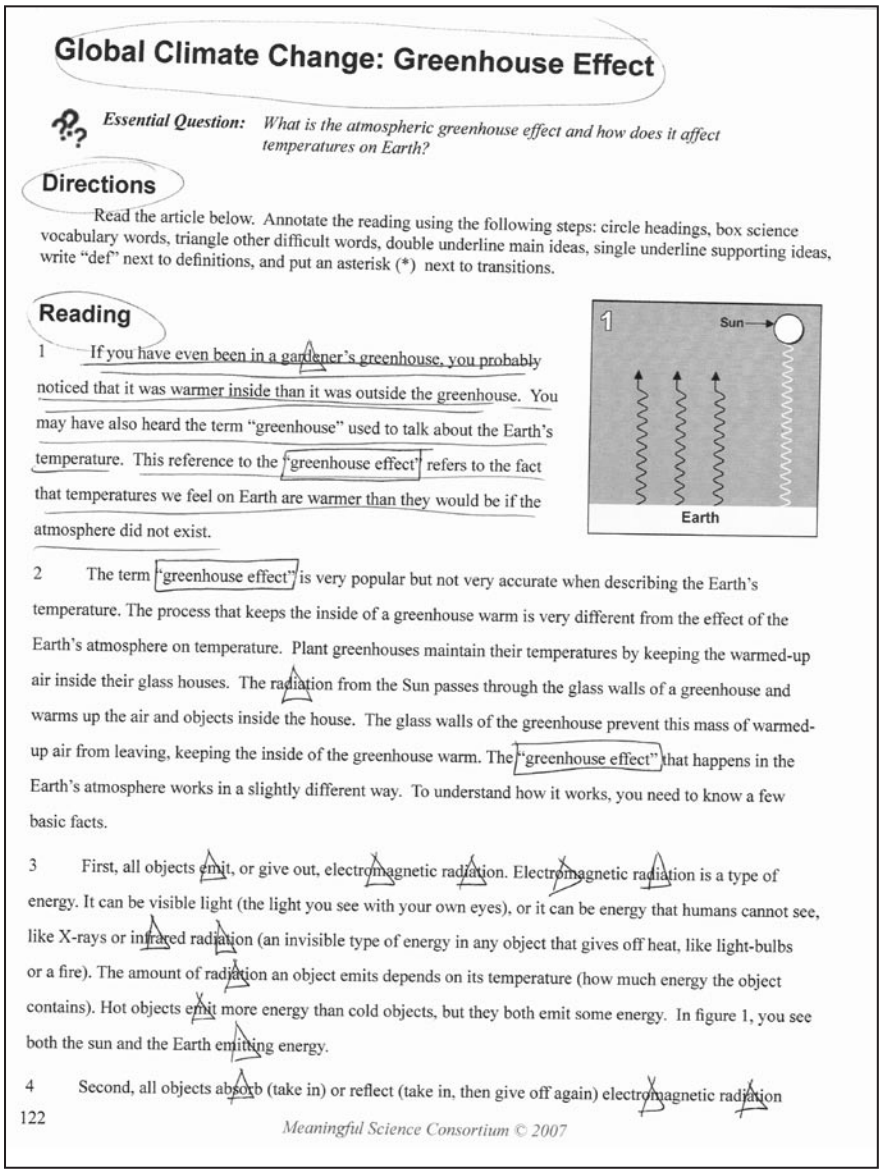
After completing steps 1–3, Ms. Granger asks her students to explain the phrase *main idea*. After a short discussion the class agrees that the main idea is the most important sentence for each paragraph or section. Ms. Granger sums up the main idea by saying it's the sentence that describes what the section is about. She explains that they will be finding the main idea for each paragraph. Ms. Granger reads the first paragraph out loud and then points out the main idea by double-underlining it on the overhead. She explains why she chose the sentence as the main idea. She then continues to read the second paragraph. She asks students for their opinions. Two students volunteer to share their answers, and they agree on the same sentence.

Ms. Granger continues to read paragraphs and ask students for the main ideas. Most of the time students agree about the main idea, but there are some instances when students do not. In these cases, Ms. Granger asks the students to explain why they chose each main idea. In one instance, a student could not provide clear reasons for his choice, but the other student could. Ms. Granger explains that the second student was able to provide good reasons for why she chose a particular main idea. The student was also able to provide supporting ideas for the main idea. Ms. Granger tells students that as long as they can accurately offer reasons and support the main idea with more information from the text they will usually be correct.

Ms. Granger asks the students to define what a supporting idea is. Students define supporting ideas as sentences that describe the main idea in more detail. She also explains that it is okay to have different answers as long as the students can support their choices. In fact, Ms. Granger is pleased because, in engaging in discussions about the main and supporting ideas of a reading, students are demonstrating their understanding of what they have read—a key goal in learning in the content areas. We've included examples of two student annotations that are similar to what Ms. Granger would have seen in her class (see Figure 2 and Figure 3).

The first few times Ms. Granger used annotation in her classroom she only used steps 1–5 and 12 (headings, vocabulary, other words, main ideas, supporting ideas, and questions). As the year goes on and students begin to master the steps, Ms. Granger adds more steps to the annotation process. As she adds new steps she always refreshes students' memories by explaining each one and giving examples. Ms. Granger always discusses the benefits of using annotation and reminds students why they are being asked to annotate. *Note to teachers: If students do not hear this repeatedly, they will not use annotation to its full potential. Also, when introducing annotation it is up to you to decide how you annotate. In the example above, Ms. Granger annotated part of the reading using one step at a time and then switched to annotating one step (main ideas) for the entire reading.*

Figure 2 Sample of Student Annotation



Global Climate Change: Greenhouse Effect

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

Directions

Read the article below. Annotate the reading using the following steps: circle headings, box science vocabulary words, triangle other difficult words, double underline main ideas, single underline supporting ideas, write "def" next to definitions, and put an asterisk (*) next to transitions.

Reading

1 If you have even been in a gardener's greenhouse, you probably noticed that it was warmer inside than it was outside the greenhouse. You may have also heard the term "greenhouse" used to talk about the Earth's temperature. This reference to the "greenhouse effect" refers to the fact that temperatures we feel on Earth are warmer than they would be if the atmosphere did not exist.

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

3 First, all objects emit, or give out, electromagnetic radiation. Electromagnetic radiation is a type of energy. It can be visible light (the light you see with your own eyes), or it can be energy that humans cannot see, like X-rays or infrared radiation (an invisible type of energy in any object that gives off heat, like light-bulbs or a fire). The amount of radiation an object emits depends on its temperature (how much energy the object contains). Hot objects emit more energy than cold objects, but they both emit some energy. In figure 1, you see both the sun and the Earth emitting energy.

4 Second, all objects absorb (take in) or reflect (take in, then give off again) electromagnetic radiation

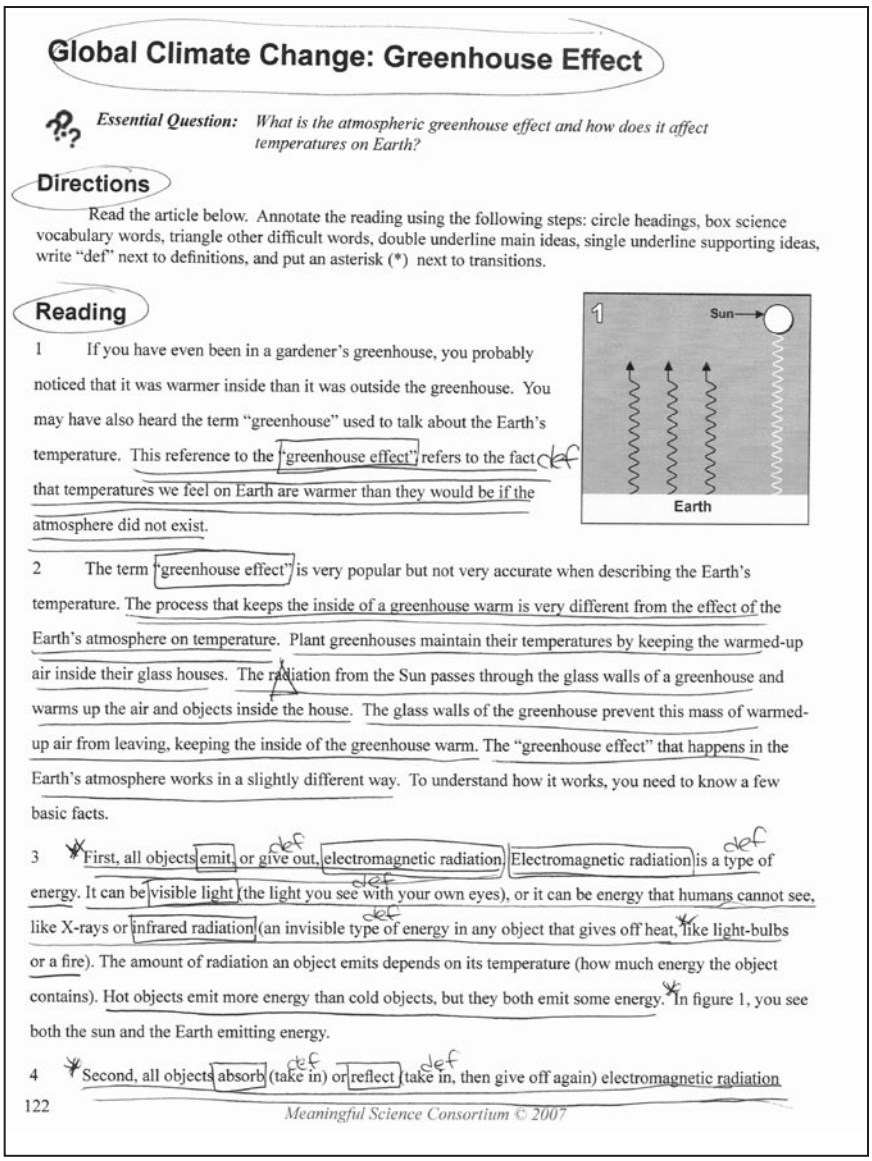
Note. Text sample from Edelson, D.C. (2005). *Investigations in Environmental Science: A Case-Based Approach to the Study of Environmental Systems.* Armonk, NY: It's About Time.

Tips for Using Annotation in the Classroom

For students just learning how to annotate it is important *not* ask students to use all of the steps at once. We recommend that teachers gradually introduce the annotation steps. This allows students to master each step before adding more. If all of the steps are required in the beginning, students feel overwhelmed and are discouraged from annotating. It is up to the individual teacher to decide when each step is introduced in the classroom. During the first two years of our project we documented how teachers introduced annotation and collected examples of student work.

Our observations indicated that learning all the annotation steps simultaneously seemed to create a kind of cognitive overload for students, which is not completely surprising. Students were being asked to read texts and identify structural elements that they

Figure 3 Sample of Student Annotation



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had likely glossed over in past reading activities. We observed that some teachers, on their own, decided to use only a few elements initially. We interviewed these teachers and observed student performance and over time determined that it works best to start with steps 1–5 and 12 in September. October is a good time to introduce steps 6–8 (procedural words, definitions, and transitions). An appropriate time to introduce steps 9 and 10 (conclusions and inferences) is in midyear (e.g., January), although this depends on the science content and the level of students. Students will have a better understanding of conclusions and inferences if they see the teacher model these steps for a few months prior to being required to do it on their own. Step 11 (equations and formulas) may be introduced at any time, depending on the content.

In order for annotation to be an effective activity in and out of the science classroom, there must be a classroom culture around annotation. Having an annotation poster in the classroom, as described earlier,

and giving students smaller versions for their notebooks will reinforce the importance, but also the regularity, of annotation as part of the daily science classroom activities. It is important for students to see it as part of their class work and not as an extra activity in addition to their science homework. The best way to do this is to ask students to annotate everything (e.g., readings, labs, instructions, newspaper articles). If students cannot write in their books, it will be essential to provide extra copies of readings for students to work on.

In our work, we have tried to ensure that each student has an opportunity to annotate each important reading. An important reading is one in which key concepts for the unit or key events in the subject matter are described. When it is not possible to have copies for every student, it may be possible to just have enough copies for students to work in groups or to annotate as a class using an overhead projector. In this case, you can ask students to use the jigsaw technique with individual paragraphs to annotate them in pairs or in small groups. Afterward, the class can come back together and review the annotations.

After the initial classroom introduction to annotation, students can be asked to complete annotations in several ways. The class can annotate as a whole group, similar to the example above. The teacher can write on the overhead, so students can easily follow and correctly annotate their copies. Another idea is to have students take turns annotating on the overhead. The teacher can call up one student at a time to complete each step. For example, one student could be asked to put a box around all vocabulary words and another student could be responsible for finding the main idea for the first section.

Yet another option is to have students annotate in pairs or groups even when each student has his or her own copy of a text. This allows students to discuss their annotations and the content as they work. Students could be split into groups and each group could be responsible for annotating a section of the reading. After each group has annotated their section one volunteer from each group could share their answers with the class by annotating a projected copy. Or the annotation could be assigned for homework and then the annotation and content can be discussed in class the next day. How the classroom is organized during an annotation activity is up to the individual teacher. The most important thing is to make sure students are engaged and discussing the key concepts through the annotation activity.

Using Annotation to Teach Content

Annotation is an excellent tool to teach content. Every time students are assigned an annotation, the answers need to be discussed in class. Through discussions, students not only become better at annotating and reading, but also they will have a more in-depth understanding of the science content presented in the reading. Rather than lecturing or using slideshow presentations, teachers can actively engage students in the learning process through annotation and discussions. Students will be able to contribute their ideas and, whether they are correct or not, discussing annotations presents the perfect opportunity to incorporate teaching the content.

Annotation also encourages students to debate correct main ideas and supporting ideas, which in turn means they are learning the foundational skills for debate and argumentation through talking, analyzing, and synthesizing the material. Learning to engage in scientific argumentation is important for science learners (Driver, Newton, & Osborne, 2000), and all learners, and is also necessary for developing expert thinking skills (Gomez & Gomez, 2007). This integration of annotation and content allows students to engage in and reflect on the work while reading (Gomez, Herman, & Gomez, 2007). According to Guthrie (2004), cognitive reading strategies, like annotation, are one way to increase student engagement around reading, along with conceptual understanding and social discourse.

We have seen annotation implemented in Environmental Science, Chemistry, Physics, and Biology courses at the high school level and in Literature, Math, Social Studies, and Science courses in grade 6. Although the content in each discipline requires some specific tweaking of the annotation steps, we have seen success. Teachers find annotation to be an extremely useful method of engaging students in the readings and content. Looking back, many teachers wish they had asked their students to annotate more frequently in the beginning of the year. After

the first year of including annotation in the classroom, most teachers choose to have students annotate more materials, rather than fewer. This being said, it is not an easy task to use a new strategy like annotation, but with time, patience, and practice teachers find it to be extremely beneficial and see results with their students' engagement, participation, and test scores (Gomez et al., under review).

Impact of Annotation

To measure the effectiveness of the strategic literacy approach, we used the Degrees of Reading Power (DRP) reading comprehension test, asked expert teachers to analyze students' annotations, and measured students' science understanding using chapter questions and a teacher-created final exam. Classrooms were observed weekly to gather data, such as frequency and consistency of strategy use. The observations took place in a large urban high school. Each of the three classes observed consisted of freshman and some sophomores. Most students were African American or Latino. The three teachers differed in their level of use of the literacy strategies and annotation. In Table 1 we present reading results based on the DRP. The DRP scores predicted science achievement across all measures including formative inquiry question performance, science essay questions, classroom science grades, and teacher-created skills tests, including students' definitions of important science terms. The strength of association ranged from 0.25 to 0.55.

Analyzing further, we found that many annotation elements were correlated with science achievement. That is, students' annotated science text results, as evaluated by expert teachers, indicated that identification of main ideas, science vocabulary, and transition words was correlated with measures of science achievement. These results suggest that students did benefit from their use of specific text strategies. Although this finding might be attributed to a wide variety of factors, and students did use two other strategies as a part of the intervention (double-entry journaling and summary writing), we are encouraged by these students' growth in reading comprehension and specifically the relationship between reading comprehension and annotation and science achievement and annotation.

Limitations of Using Annotation in the Content Areas

Unfortunately there are a few limitations when trying to implement annotation in the classroom. It may be difficult to access the resources needed to make annotation a success. For example, teachers need to be able to make copies of readings for students to write on and need to provide copies of the annotation steps for their students. Teachers should also have a poster of the annotation steps in their classrooms. For some teachers this may be a major hindrance to doing annotation.

Another limitation of using annotation is that it may be difficult for teachers to use new literacy strategies. Many teachers have little or no experience using literacy strategies in the content areas. It may be a difficult adjustment for some, but with practice teachers

Table 1 Growth in Reading Achievement Based on Degrees of Reading Power (DRP) Scores From October (Pre) to May (Post)

	(Most use of intervention) *N* = 43		(Mid-range use of intervention) *N* = 37		(Inconsistent use of intervention) *N* = 30	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Total items correct	32.44	38.77	41.78	46.97	31.53	34.47
DRP score, P = 0.90 (independent reading level)	41.47	46.44	48.81	53.35	40.37	42.90
Percentile rank (based on nationally normed sample)	19.49	27.93	33.11	42.84	18.73	22.07

should be well equipped to teach the strategies and teach the content via the strategies.

As in the examples provided by Conley (2008), it could be very easy for teachers to use annotation repeatedly in hopes that students will pick up on its purpose and function, rather than using annotation as a means to get students to critically develop their reading skills and to gain content knowledge. Teachers must explicitly connect annotation and the content. Teachers should avoid teaching annotation as a separate task and instead introduce it as an integrated resource and skill for learning content. While it remains unclear how cognitive strategies like annotation are applied and transferred into other content areas and environments (Conley, 2008), our work suggests that tightly coupling annotation to content benefits student learning.

Annotation Builds Independent Learning Skills

We have learned several important lessons that are useful for teachers who want to help students learn to read and understand more in the content areas, such as science. We know that high school students struggle with reading science materials. We also know that consistent use of annotation in science classrooms helps students read more carefully and reflectively and builds on their independent learning skills. We know that the reading-to-learn tools, like annotation, must be carefully tied to the intended science learning and not haphazardly or inconsistently applied. If teachers are invested in using a literacy strategy to help their students deeply understand what they are reading, then the benefits of deeper comprehension and better science learning are definitely worthwhile.

In order for students to be successful in high school, they need to have the skills to read complex text. Teachers often worry that there is barely enough time for content learning without the addition of reading activities. We believe that when students learn to read more effectively, they will learn the content more deeply. Thus, less time must be spent on reiterating concepts that students should have learned days or weeks before. Using approaches like annotation to support students' reading-to-learn skills in content areas like science is a "win" for teachers and students alike.

References

Armbruster, B.B., & Anderson, T.H. (1988). On selecting "considerate" content area textbooks. *Remedial and Special Education*, *9*(1), 47–52.

Conley, M. (2008). Cognitive strategy instruction for adolescents: What we know about the promise, what we don't know about the potential. *Harvard Educational Review*, *78*(1) 84–108.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, *84*(3), 287–312. doi:10.1002/(SICI)1098237X(200005)84:3<287::AID-SCE1>3.0.CO;2-A

Edelson, D.C. (2005). *Investigations in environmental science: A case-based approach to the study of environmental systems*. Armonk, NY: It's About Time.

Gomez, K., Gomez, L., & Herman, P. Conspicuous strategies to support reading to learn: Preparing urban youth to engage in science inquiry. *American Educational Research Journal*. Manuscript under review.

Gomez, L., & Gomez, K. (2007). Reading for learning: Literacy supports for 21st century work. *Phi Delta Kappan*, *89*(3), 224–228.

Gomez, L., Herman, P., & Gomez, K. (2007). Integrating text in content-area classes: Better supports for teachers and students. *Voices in Urban Education*, *14*, 22–29.

Guthrie, J.T. (2004). Teaching for literacy engagement. *Journal of Literacy Research*, *36*(1), 1–29. doi:10.1207/s15548430jlr3601_2

Levy, F., & Murnane, R.J. (2004). *The new division of labor: How computers are creating the next job market*. Princeton, NJ: Princeton University Press.

Pressley, M. (2000). What should comprehension instruction be the instruction of? In M.L. Kamil, P.B. Mosenthal, P.D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 545–562). Mahwah, NJ: Erlbaum.

Pressley, M. (2006). *Reading instruction that works: The case for balanced instruction*. New York: Guilford.

Pressley, M., & Wharton-McDonald, R. (1997). Skilled comprehension and its development through instruction. *School Psychology Review*, *26*(3), 448–466.

Sherer, J., Gomez, K., Herman, P., Gomez, L., White, J., & Williams, A. (2008). Literacy infusion in a high school environmental science curriculum. In K.R. Bruna & K. Gomez (Eds.), *The work of language in multicultural classrooms: Talking science, writing science* (pp. 93–114). Mahwah, NJ: Routledge-Taylor Francis.

Yore, L., Shymansky, J., Henriques, L., Chidsey, J., & Lewis, J. (1997). *Reading-to-learn and writing-to-learn science activities for the elementary school classroom*. In P. Rubba, P. Kieg, & J. Rye. In *Proceedings of the 1997 Annual International Conference of the Education of Teachers in Science* (pp. 40–72). Retrieved from www.ed.psu.edu/ci/Journals/97pap1.htm

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