



# Learning to Write and Writing to Learn in Science

## Refutational Texts and Analytical Rubrics

by Amy Dlugokienski and Victor Sampson

**M**ost middle school science teachers are familiar with the idea of reading and writing across the curriculum. We, as science teachers, understand that our students need time, practice, and lots of encouragement in order to learn how to read and write well. What we also need to remember, however, is that learning how to read and write in science is an important part of scientific literacy, and it can help students understand and retain key science content (NRC 1996; Saul 2004). In this article, we outline a technique that science teachers can use in middle school classrooms to help students learn to write, and write to learn, in science.

### Why are reading and writing so important in science?

Science teachers need to help students learn how to read and write in science for a number of reasons:

- Students need to know how to learn about science on their own if we expect them to be lifelong learners. This requires students to be able to read, understand, and critique academic, nonfiction, and persuasive genres of writing.
- Reading and writing are important aspects of doing science. Scientists must be able to read and understand the writing of others, evaluate its worth, and share the

results of their own research through writing.

- All students, regardless of their interest in a scientific career, need to be able to read and write about scientific issues so they can make educated decisions and participate in a democratic society.
- Students who are skilled at reading and writing in science are often able to learn the concepts, theories, models, and laws of science more deeply and retain more than students who are not (Shanahan 2004).

It is important to remember, however, that students will not learn how to read or write in science by read-

ing novels or by writing short stories in language arts. Students need to be introduced to the various genres of science writing and how to combine words and symbols to create meaning in a manner that is consistent with the stylistic rules of science. They also need to practice this type of writing and receive good feedback about the quality of their writing so they have an opportunity to improve. It is therefore important for science teachers to engage students in real science writing as part of their science education. One effective way to do this is to give students opportunities to write *refutational texts* as part of their experiences in science.





## Refutational texts

A refutational text introduces a common concept, idea, or theory; refutes it; offers an alternative concept, idea, or theory; and then attempts to show that this alternative way of thinking is more valid or acceptable. An example of a refutation can be seen in this excerpt below (the key sentence that identifies this passage as a refutational text is italicized).

Many people believe that a change in the Earth's distance from the Sun causes the seasons to change. *However, this cannot be true, because the seasons are different in the Northern and Southern Hemispheres.* The actual cause of the seasons is the way the Earth is tilted on its rotational axis. When the Earth's axis points toward the Sun, it is summer for that hemisphere. When the Earth's axis points away, it is winter for that hemisphere. This is because the hemisphere that points toward the Sun receives more direct sunlight and has longer days.

A refutational text, such as the example provided here, is one of three kinds of persuasive arguments that are often found in scientific writing (Hynd 2003). A one-sided persuasive argument only presents the concept, idea, or theory the author prefers a reader to adopt. Two-sided arguments can be nonrefutational or refutational. A two-sided, nonrefutational argument presents both sides of an issue, but makes one side seem stronger by presenting more evidence, explaining it more logically, or in some other way making the argument more compelling without explicitly stating that the author prefers it. A refutational argument, in contrast, is more explicit than a nonrefutational argument about which is the preferred side.

Most textbooks and science trade books are written in an expository or narrative style and usually do not include persuasive arguments. When they do, they often use one-sided arguments rather than refutational, two-sided arguments. Thus, students are likely to be unfamiliar with this type of writing and will need explicit instruction, a great deal of practice, and good feedback in order to learn how to write in this manner. Science teachers, however, can help students learn to write high-quality refutational texts (and to learn more content as part of the process) by using writing prompts coupled with analytical rubrics that provide students with feedback about their performance and teachers with insight about what students can and cannot do.

## Writing prompts

A well-designed writing task in science essentially has three critical attributes:

- it provides an authentic purpose for writing;
- it motivates students to want to write; and
- it helps students plan and structure their writing (Turner and Broemmel 2006).

These three attributes, when made explicit to students, make the goal of a writing assignment understandable, the writing meaningful, and a high-quality product achievable. One way to ensure that a writing task has each of

**FIGURE 1** Refutational writing prompt

What causes water to appear on the outside of a container?

People tend to believe that water from the inside of a container seeps through to the outside after a period of time. Write a one- to two-page paper to refute the claim that water from the inside of a container leaks through to the outside to convince someone that this is a misconception.

As you write the paper, remember to do the following:

- State the misconception you are trying to refute
- Include evidence from a lab experiment, research that you have done, topics from the class discussions, and examples to convince your audience to abandon this misconception
- Organize your paper properly and include an introduction with a topic sentence, supporting paragraphs, and a conclusion
- Use vocabulary that we have learned
- Correct grammar, punctuation, and spelling errors before writing your final draft

You will have two class periods to complete this assignment. The first period will be dedicated to planning and creating a rough draft and the second period will be spent revising and creating a final draft of the paper. The paper will be due at the end of the class period on day 2.

### Outline

Create an outline for your paper explaining the misconception, the evidence against it, and justification for the evidence. Use this to help you write your rough draft.

### Rough draft

Write a rough draft of your refutational text. After you complete the draft, use a different color pen to correct your work. Be sure to look for spelling and grammatical errors. You may use a dictionary or a grammar book if you need.

### Final draft

Write the final draft of your refutational text.

**FIGURE 2** Example of a refutational-text grading rubric**Section 1: Outline**

Criterion	3 points	2 points	1 point
Topics/Format	Most points are made in a clear outlined fashion. The outline is neat and orderly.	Some points are presented or the format of the outline is missing. Most of the outline is presented in an organized manner.	Outline is incomplete and flawed. The outline is messy and disorganized.

Total: \_\_\_\_/3 points

Comments:

**Section 2: Rough draft**

Criterion	3 points	2 points	1 point
Editing	The draft is edited in a different color pen. All grammatical errors are highlighted and corrected.	Some errors were missed or the draft is not edited in a different color.	Many errors were missed and the draft is not edited with a different color. Directions were not followed and a revision was disregarded.

Total: \_\_\_\_/3 points

Comments:

**Section 3: Final draft**

Criterion	3 points	2 points	1 point
Organization/ Grammar	The paper is free of grammatical errors. The flow of the paper has a beginning, middle, and end.	There are few grammatical errors. The paper is somewhat lacking in organization.	The draft is incomplete and sloppy. The draft is disorganized.

Total: \_\_\_\_/3 points

Comments:

**Section 4: Content accuracy**

Criterion	3 points	2 points	1 point
The misconception is identified	The writer identifies a misconception and explicitly states why it is inaccurate.	The writer identifies the misconception, but fails to explain that the misconception is inaccurate.	The misconception is buried, confused, and/or unclear. The misconception is disregarded.
Reasons against the misconception	The writer provides several reasons why the misconception cannot be true. The reasons are explained clearly.	The writer provides a few reasons that show why the misconception is inaccurate but leaves some reasons out. The explanations may be unclear.	The writer does not acknowledge or discuss any reasons for why the misconception is inaccurate. The writer may also have incorrect explanations.
Evidence and reasoning in support of the scientific conception	The writer gives a clear and accurate explanation of the scientific conception. The writer illustrates why it is more useful than the misconception.	The writer gives a vague or somewhat inaccurate explanation of the scientific conception. There are some reasons provided to support the scientific conception.	The writer makes no mention of the scientific conception. The writer provides no evidence or reasoning.

Total: \_\_\_\_/9 points

Comments:

Final Total: \_\_\_\_/18 points

these attributes is to use a structured writing prompt (Indrisano and Paratore 2005). A structured writing prompt begins with all the information a student will need in order to write (the topic, the audience, the purpose, the form of the text, and reminders). It then outlines the steps of the writing process (e.g., creating an outline, producing a rough draft, editing, and preparing a final draft) and provides space for the student to complete each step. An example of a structured writing prompt that encourages students to write a refutational text about the concept of condensation is provided in Figure 1. In this prompt, students are asked to produce a one-page essay (the form of the text) that refutes the claim that water from inside a container leaks through to the outside (the topic and the purpose of the text) for a group of people who believe that this claim is true (the audience of the text). The prompt also reminds the writer to state the misconception that they are trying to refute, to use evidence to support their claim, and to organize their writing in an appropriate manner. These reminders are designed to focus the writer's attention on important components of a quality refutational text that novices often forget or do not provide enough attention to in their writing.

Teachers should keep four issues in mind when designing these types of writing prompts. First, students need to refute a common misconception related to a big idea in the curriculum. This will help students learn the content required by the district, state, or national science standards, and it will give them an authentic purpose for writing. It will also motivate students to want to write. Teachers can find lists of common misconceptions by entering a topic (e.g., condensation) and the terms "misconception" or "alternative conception" into an internet search engine. Teachers can also uncover any specific misconceptions held by their students by simply asking them to explain an everyday occurrence. They could also use students' science journals or bell-work questions as ways for students to explain these occurrences and then as a source for student misconceptions. Second, teachers need to be sure that the "reminders" included in the writing prompt will help students plan and structure their writing. These reminders should help focus students' attention on the goal of the writing assignment, the 6 + 1 traits of writing (Culham 2003), or specific writing requirements outlined in district or state language arts standards. Third, teachers need to be sure that students complete each step of the writing process (outline, rough draft, editing, and final draft). This will encourage students to keep their thoughts organized and to look over their work before they are ready to submit the final product. Finally, the writing prompt needs to be coupled with an analytic rubric that can be used to inform and improve student perfor-

mance. This way, both the student and teacher know what is expected and what needs to be done to improve.

### Analytical rubrics

Analytical rubrics are designed to provide information that can be used to determine students' current level of achievement, diagnose their strengths and weaknesses, and allow them to learn more about what they know or can do. Also, and perhaps most importantly, it shows what they need to do in order to improve (Hodson 1992). Analytical rubrics are matrices that identify what is expected of students by defining important criteria that will be used to assess quality and various performance levels. To increase the clarity of this type of rubric, each criterion is "subdivided into more concise statements and then followed by the related performance descriptions" (Luft 1997). An example of an analytical rubric that we developed to assess students' understanding and their ability to produce a quality refutational text is provided in Figure 2. In this example, the analytic rubric consists of four sections (outline, content, etc.) that are divided into one or more criteria (the misconception is identified, etc.), which are followed by descriptions that illustrate three distinct levels of performance.

The multilevel nature of an analytical rubric can help teachers uncover specific strengths and weaknesses. The rubric can also be used to help students understand the criteria to which they will be evaluated. Analytical rubrics, perhaps more importantly, can also provide detailed feedback to students about their performance. This kind of detailed information about what a student is doing right and wrong is a key component of an assessment that is educative in nature (Wiggins 1998). It also enables teachers to examine the strengths and weaknesses of their curriculum and methods of instruction. Middle school teachers can use all this information to help students enhance their understanding of the important concepts and what counts as quality when writing in science.

### An example lesson

To illustrate how this writing prompt, coupled with the analytical rubric, can be integrated into a science lesson, consider the following example lesson. This lesson begins with the classroom teacher pouring ice water into a drinking glass. Students are then directed to watch the glass and record their observations. After several minutes, condensation begins to form on the outside of the glass. The teacher then encourages students to explain the origin of this water. The teacher writes each explanation (right or wrong) on the board and then leads the class in a discussion that focuses on ways to test the various explanations (such as using hot water instead of cold or water colored

with food coloring inside the glass). These tests are then carried out by the teacher or by small groups of students and the results are used to weed out the inaccurate explanations until the class agrees on the scientific explanation (i.e., water vapor in the air turns back into a liquid when it touches the cold glass).

The next day, students are given the writing prompt (see Figure 1) and the analytical rubric (see Figure 2) and are told to use their knowledge and the data they gathered to refute the idea that the water leaks from the glass. Students then submit their texts to the teacher or to one or more of their peers for an initial evaluation. This process is guided by the analytical rubric, which, as noted earlier, outlines the criteria that are to be used to evaluate the quality of text and space to provide feedback to the student. It is important for the evaluators to not only provide information about how the text should be scored (by circling values for each criterion) but to also provide explicit narrative feedback to the student about what needs to be done in order improve the quality of the text. This feedback needs to focus on both the quality of the writing (section 1–3 in the example rubric) and the accuracy of the content (section 4 in the example rubric) so the student knows what needs to be revised (e.g., understanding of the content, the organization or conventions of the writing, or all three). The texts and the rubric are then returned to students with directions to use the feedback to improve their final product. Students then rewrite their texts as necessary and resubmit the assignment for a final grade. This type of review process provides students with educative feedback, encourages students to develop and use appropriate standards for what counts as quality, and helps students be more reflective as they work. This type of feedback also provides a mechanism that can help all students, especially special-needs and ESOL learners, improve their ability to write in science, and ensure that all students understand the content. If you have special-needs or ESOL students in your class, you could modify the time constraints to be longer so as to allow them more time on the assignment. Since the rubric in Figure 2 is divided into sections, it makes it easy for the teacher to see if it is the content knowledge (section 4) that students don't understand or if they are just having difficulty with the language or the writing of the assignment (sections 1, 2, and 3). This review process requires about five to ten minutes for an evaluator to complete.

### Why is this important?

This writing process helps students make sense of their experiences by requiring them to explain a phenomenon and by refuting a common misconception in writing. This promotes understanding and retention of the content

(writing to learn) and makes their thinking visible to the teacher. This process also gives them a meaningful opportunity to improve their ability to communicate through writing (learning to write). The writing prompt provides an authentic purpose for writing, motivates students, and helps them plan and structure their writing. The analytical rubric then provides students with the guidance and feedback that they need in order to improve their ability to write. As a result, this lesson provides a way to support efforts to promote writing across the curriculum (which is clearly needed) in a way that fosters student understanding of important content and writing in science. ■

### References

- Culham, R. 2003. *6 + 1 traits of writing: The complete guide*. New York: Teaching Resources/Scholastic.
- Hodson, D. 1992. Assessment of practical work. *Science and Education*. 1 (2): 115–44.
- Hynd, C. 2003. Conceptual change in response to persuasive messages. In *Intentional conceptual change*. G. Sinatra and P. R. Pintrich, eds. Mahwah, NJ: Lawrence Erlbaum Associates.
- Indrisano, R. and J. Paratore, eds. 2005. *Learning to write and writing to learn: Theory and research in practice*. Newark, DE: International Reading Association.
- Luft, J. 1997. Design your own rubric. *Science Scope*. 20 (5): 25–27.
- National Research Council (NRC). 1996. *National science education standards*. Washington, D.C.: National Academies Press.
- Saul, E.W., ed. 2004. *Crossing borders in literacy and science instruction: Perspectives on theory and practice*. Arlington, VA: NSTA Press.
- Shanahan, C. 2004. Better textbooks, better readers and writers. In *Crossing Borders in Literacy and Science Instruction: Perspectives on Theory and Practice*, W. Saul, ed. Arlington, VA: NSTA Press.
- Turner, T., and A. Broemmel. 2006. 14 writing strategies. *Science Scope* 30 (4): 27–31.
- Wiggins, G. 1998. *Educative assessment: Designing assessment to inform and improve student performance*. San Francisco: Jossey-Bass.

**Amy Dlugokienski** (amy.marie.dlugokienski@gmail.com) is an eighth-grade science teacher at Beth Shields Middle School in Ruskin, Florida. **Victor Sampson** (vsampson@fsu.edu) is an assistant professor of science education at Florida State University in Tallahassee, Florida.