More Than Writing-

Using multimodal writing tasks in science classrooms

Mark McDermott

"I'm not an English teacher, so I can't use writing assignments in my class."
"I can't take time—that could be used for 'real' science activities—to set up, assign, and grade written products."

These are two of the thoughts that ran through my mind when my graduate studies advisor suggested I try "writing-to-learn" activities in my classes. Like many high school science teachers, I often thought that devoting class time to writing would take away from valuable time that could be spent doing "science learning" activities. I also felt that my training as a science teacher had not fully prepared me to instruct about or evaluate these kinds of assignments in the classroom.

However, as I encountered the growing body of research on writing-to-learn activities and their potential benefits (Prain 2006; Wallace, Hand, and Prain 2004), I gradually began to change my mind. Writing-to-learn activities are designed to use writing as a process in which students generate and clarify understanding of scientific concepts for themselves, rather than simply communicating with a teacher for evaluation. Instead of having students parrot science facts back to the instructor, writing-to-learn activities focus on the production of nontraditional writing assignments—such as poems, brochures, or letters—to develop student understanding (Yore and Treagust 2006).

In addition, I found that recent definitions of *science literacy* emphasize the literacy component (Yore, Bisanz, and Hand 2003; Norris and Phillips 2003), so I began to search for classroom activities that would improve students' reading and writing skills. This search led to my use of one particular kind of writing-to-learn activity called a multimodal writing task. Through these tasks, students combine different modes of representing information—such as graphs, diagrams, charts, mathematical equations, or pictures—with text to create a more complete description of the science concepts being studied. This article highlights my experience using multimodal writing tasks and their impact on student learning in my high school biology and chemistry classrooms.

Writing-to-learn in science classes

Using writing in science classrooms is not a novel idea. High school science students often communicate their understanding of a particular concept in some kind of written form for evaluation. However, current research aimed at viewing writing as a process that can help students develop and generate knowledge is leading to more widespread use of writing-to-learn tasks (Galbraith and Torrance 1999).

The goal of these tasks is to have students learn science concepts by conveying their conceptual understanding—in their own words—to authentic audiences. Authentic audiences are composed of people outside of the classroom who read and evaluate the written product. In the past, I have used parents, peers outside of our class, or even an elementary school class whose teacher was willing to have the students volunteer as authentic audiences. In doing so, students translate the information they have encountered in class through discussion, lab activities, or research into everyday vocabulary that can be used to explain their understanding to someone who is unfamiliar with the concepts (Prain and Hand 1996). This often leads to a realization that the student's initial understanding was inadequate or lacking some detail, initiating a process in which he or she strives to improve understanding and then communicate this new understanding. Ideally, this cycle promotes learning, as opposed to students simply repeating vocabulary they hear but may not necessarily understand (Gunel, Hand, and McDermott 2009). Prain and Hand (1996) suggest that asking students to create nontraditional science writing products may initiate this cognitive process (Yore and Treagust 2006).

My initial attempts at using writing-to-learn tasks were based on a model suggested by Prain and Hand (1996), in which the teacher considers the topic, type, audience, means

FIGURE 1

Strategies for embedding alternative modes in text.

1. Place the mode near the text that deals with the related concept.
2. Refer to the mode in the text (e.g., "Please refer to Figure 1.").
3. Include a caption with the mode summarizing what it describes.
4. Create the mode yourself rather than using a mode someone else created.

FIGURE 2

Progression of the lesson.

1. The teacher presents a lesson highlighting embeddedness strategies.
2. Students create an embeddedness assessment checklist.
3. The multimodal writing activity is assigned.
4. The assignment is evaluated by an authentic audience and then returned with feedback.
5. Students use the embeddedness assessment rubric they created to self-assess their multimodal assignments. A sample rubric is available (see "On the web").
6. The final product is turned in to the teacher.
7. Students take the end-of-unit assessment.

to-Learn

of text production, and curricular purpose for the writing in setting up the task. My students participated in activities such as writing letters about stoichiometry to seventh graders, creating storybooks about the circulatory system for third graders, and designing magazine articles about atomic structure for their peers. These tasks provided some benefit for my students, who improved their scores on end-of-unit evaluations. This is consistent with research reporting conceptual improvement, greater grasp of the nature of science, and improved metacognition (Gunel, Hand, and McDermott 2009).

However, as I used more of these writing-to-learn tasks, I realized that for some students, the creation of text-only writing was daunting, not because of the science issues involved, but because of their difficulties and discomfort with writing skills. I realized that I needed to create writing activities structured to give students alternatives for expressing their understanding. Discussing this issue with my colleagues led to the idea of creating multimodal writing activities, in which students can choose to include other methods of explaining science information, such as pictures, charts, graphs, diagrams, and mathematical expressions, in addition to text.

Exploring multimodal writing tasks

The multimodal writing tasks I set up were similar to the writing-to-learn tasks I had used previously, in which students created nontraditional products for authentic audiences. However, for these modified tasks, students were required to use at least one mode of representation other than text. Several factors indicated the potential benefits of these types of tasks:

1. *Student achievement is not dependent on writing skill alone:* Using different modes of representation provided students who were not strong writers, were lacking confidence in their writing skills, or were not motivated to produce written products with an alternative way to express their understanding.
2. *Scientists use multiple modes of representing information:* Scientists use many different modes when communicating their ideas in journal articles or the popular press. Therefore, multimodal tasks serve as authentic representations of science processes, including how scientists communicate (Gunel, Hand, and Gunduz 2006).
3. *Students are familiar with multimodal environments:* Everyday life is more multimodal than ever. Through the internet and other technology tools, students encounter, communicate with, and respond to multiple modes of representation on a daily basis. The use of multimodal products may be more familiar to students and thus may be a motivating factor.
4. *Consideration of relationships between modes increases understanding:* It was my hope that asking students to present information in a variety of formats would encourage them to consider how different modes fit together to describe a related concept—and this would lead to a more developed understanding.

With these factors in mind, I designed my first multimodal task and presented it to my students. To my dismay, the products they created did not meet my expectations, nor did they lead to any noticeable benefits.

Improving the multimodal learning process

The most obvious problem with the products of this first assignment was that almost all of my students simply added an alternative mode at the end of their written text to fulfill the requirement. There was little or no consideration given to how the different modes could work together to communicate the overall idea, and therefore the activity offered little benefit beyond that of a writing-only task.

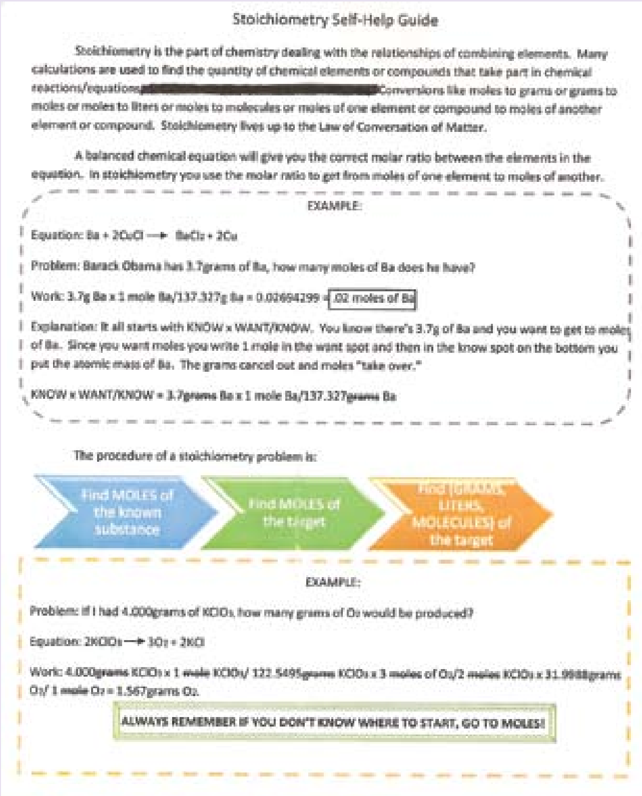
In my next attempt at a multimodal assignment, I included a lesson specifically designed to highlight strategies that authors commonly use to integrate different modes within a text. This characteristic was termed *embeddedness.* In general, embeddedness refers to the purposeful use of strategies to connect all of the different modes used in a written product. In the embeddedness-encouraging lesson, students were asked to first locate different modes in common science sources, such as textbooks, journal articles, or magazines. They then identified the strategies authors used to tie information from the text to information from an alternative mode of representation, and explained how this created a well-integrated product. Figure 1 (p. 33) lists several examples of embeddedness strategies.

After discussing these strategies, students created a checklist that could be used to evaluate a multimodal product and determine whether the alternative modes were effectively embedded in the text. They then created small-scale models of well-embedded multimodal products, such as posters, to evaluate and share with the class. Students also received feedback on early drafts from their authentic audience. Finally, students used the checklist to self-evaluate their drafts and assess their own level of integration. Figure 2 (p. 33) provides a progression of the lesson.

The results of this second experience were much more encouraging. Not only did students improve their integration of the different modes, but their performance on the end-of-unit assessment was strongly correlated with the degree of embeddedness. In fact, the correlation between the degree of embeddedness in student writing and overall scores on unit tests following the final multimodal writing task were all significant ($p < .05$). In general, students who successfully integrated their written text with alternative modes were also more successful on the end-of-unit assessment. Many

FIGURE 3

Sample multimodal products.



Stoichiometry Self-Help Guide

Stoichiometry is the part of chemistry dealing with the relationships of combining elements. Many calculations are used to find the quantity of chemical elements or compounds that take part in chemical reactions/equations[redacted]Conversions like moles to grams or grams to moles or moles to liters or moles to molecules or moles of one element or compound to moles of another element or compound. Stoichiometry lives up to the Law of Conversation of Matter.

A balanced chemical equation will give you the correct molar ratio between the elements in the equation. In stoichiometry you use the molar ratio to get from moles of one element to moles of another.

EXAMPLE:

Equation: Ba + 2CuCl → $BaCl_2$ + 2Cu

Problem: Barack Obama has 3.7grams of Ba, how many moles of Ba does he have?

Work: 3.7g Ba x 1 mole Ba/137.327g Ba = 0.02694299 = .02 moles of Ba

Explanation: It all starts with KNOW x WANT/KNOW. You know there's 3.7g of Ba and you want to get to moles of Ba. Since you want moles you write 1 mole in the want spot and then in the know spot on the bottom you put the atomic mass of Ba. The grams cancel out and moles "take over."

KNOW x WANT/KNOW = 3.7grams Ba x 1 mole Ba/137.327grams Ba

The procedure of a stoichiometry problem is:

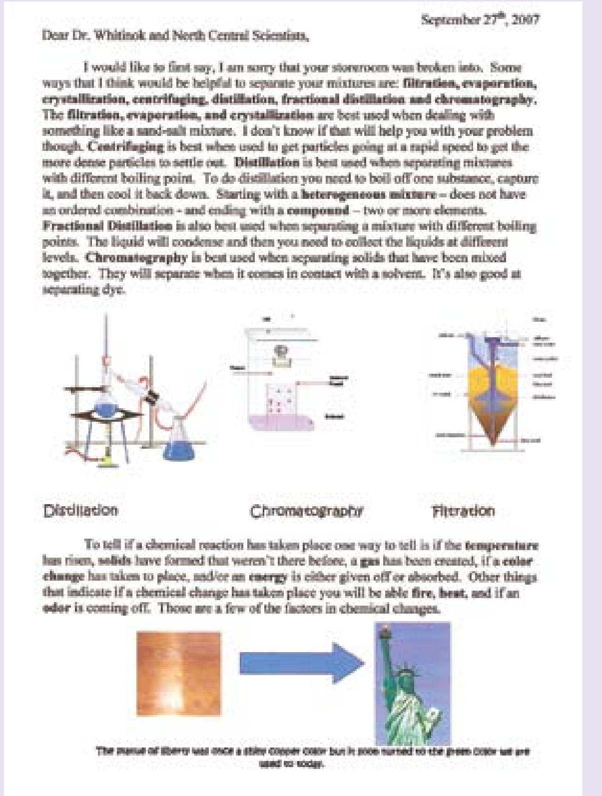
EXAMPLE:

Problem: If I had 4.000grams of $KClO_3$, how many grams of O_2 would be produced?

Equation: $2KClO_3$ → $3O_2$ + 2KCl

Work: 4.000grams $KClO_3$ x 1 mole $KClO_3$/ 122.5495grams $KClO_3$ x 3 moles of O_2/2 moles $KClO_3$ x 31.9988grams O_2/ 1 mole O_2 = 1.567grams O_2.

ALWAYS REMEMBER IF YOU DON'T KNOW WHERE TO START, GO TO MOLES!



September 27th, 2007

Dear Dr. Whitinok and North Central Scientists,

I would like to first say, I am sorry that your storeroom was broken into. Some ways that I think would be helpful to separate your mixtures are: **filtration, evaporation, crystallization, centrifuging, distillation, fractional distillation and chromatography**. The **filtration, evaporation, and crystallization** are best used when dealing with something like a sand-salt mixture. I don't know if that will help you with your problem though. **Centrifuging** is best when used to get particles going at a rapid speed to get the more dense particles to settle out. **Distillation** is best used when separating mixtures with different boiling point. To do distillation you need to boil off one substance, capture it, and then cool it back down. Starting with a **heterogeneous mixture** – does not have an ordered combination - and ending with a **compound** – two or more elements. **Fractional Distillation** is also best used when separating a mixture with different boiling points. The liquid will condense and then you need to collect the liquids at different levels. **Chromatography** is best used when separating solids that have been mixed together. They will separate when it comes in contact with a solvent. It's also good at separating dye.

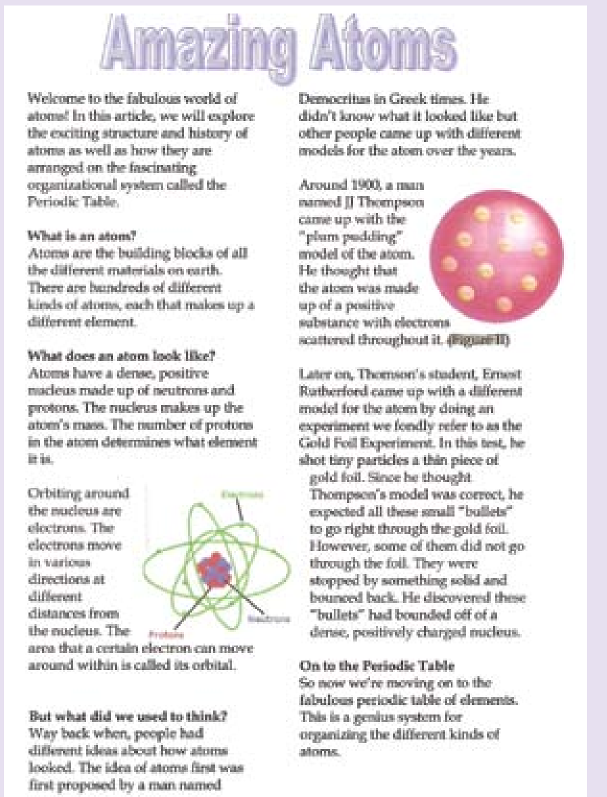
Distillation Chromatography Filtration

To tell if a chemical reaction has taken place one way to tell is if the **temperature** has risen, **solids** have formed that weren't there before, a **gas** has been created, if a **color change** has taken to place, and/or an **energy** is either given off or absorbed. Other things that indicate if a chemical change has taken place you will be able **fire, heat,** and if an **odor** is coming off. Those are a few of the factors in chemical changes.

The statue of liberty was once a shiny copper color but it soon turned to the green color we are used to today.

students who had struggled with science concepts in the past or with previous text-only tasks showed improvement in both conceptual understanding and in performance on the multimodal task. In fact, correlations between degree of embeddedness and overall student performance were strongest with lower-achieving students—meaning that multimodal tasks may be more beneficial for helping lower-achieving students gain a better grasp of science concepts.

I recently compared student performance between classes that received the embeddedness-training lesson with classes that did not receive the lesson in classrooms taught by four different teachers. These teachers taught the embeddedness lesson to only half of their classes. In all cases, classes receiving the integration lesson had higher levels of embeddedness in their writing; in three of the four cases, classes receiving the lesson had significantly higher end-of-unit exam scores on at least one assessment measure. These relationships certainly do not guarantee that multimodal tasks cause greater student learning, but the consistently positive relationship between the level of embeddedness and student performance on end-of-unit assessments suggests these tasks are useful in the classroom. Figure 3 provides examples of different multimodal writing products.



Amazing Atoms

Welcome to the fabulous world of atoms! In this article, we will explore the exciting structure and history of atoms as well as how they are arranged on the fascinating organizational system called the Periodic Table.

What is an atom?
Atoms are the building blocks of all the different materials on earth. There are hundreds of different kinds of atoms, each that makes up a different element.

What does an atom look like?
Atoms have a dense, positive nucleus made up of neutrons and protons. The nucleus makes up the atom's mass. The number of protons in the atom determines what element it is.

Orbiting around the nucleus are electrons. The electrons move in various directions at different distances from the nucleus. The area that a certain electron can move around within is called its orbital.

But what did we used to think?
Way back when, people had different ideas about how atoms looked. The idea of atoms first was first proposed by a man named Democritus in Greek times. He didn't know what it looked like but other people came up with different models for the atom over the years.

Around 1900, a man named JJ Thompson came up with the "plum pudding" model of the atom. He thought that the atom was made up of a positive substance with electrons scattered throughout it. (Figure II)

Later on, Thomson's student, Ernest Rutherford came up with a different model for the atom by doing an experiment we fondly refer to as the Gold Foil Experiment. In this test, he shot tiny particles a thin piece of gold foil. Since he thought Thompson's model was correct, he expected all these small "bullets" to go right through the gold foil. However, some of them did not go through the foil. They were stopped by something solid and bounced back. He discovered these "bullets" had bounded off of a dense, positively charged nucleus.

On to the Periodic Table
So now we're moving on to the fabulous periodic table of elements. This is a genius system for organizing the different kinds of atoms.

Student feedback

More powerful evidence of the benefit that these kinds of tasks offer, however, has come from the students themselves. In general, student comments for this assignment indicated that while they found these tasks more challenging than other classroom activities, they felt that the activities allowed them to more fully understand the concepts. Many students noted the benefit of dealing with a concept in multiple ways and seeing how different modes can communicate the same "big idea." In addition, students enjoyed being able to display their scientific understanding in whatever way they felt most comfortable and confident. The process of selecting the mode of representation was helpful in clarifying their understanding. Many students also noted that these tasks did not allow them to "hide behind vocabulary terms" and that they really had to consider and develop their science understanding to accomplish the multimodal tasks assigned. Finally, while some students felt these types of "language arts" tasks had no place in science classrooms, the vast majority indicated that it was helpful, productive, effective, and even "normal" to use writing skills in a science classroom.

Reflection

My colleagues and I have now used a number of multimodal writing tasks in our classrooms. Figure 4 lists several examples that have been used or considered. From my experience, I have noticed a few key issues that impact student success. First, as discussed, the benefit of asking students to use multiple modes is dramatically improved when these modes are successfully integrated into the text—this integration improves when students experience the lesson on embeddedness strategies. Therefore, the structure of the prewriting, embeddedness-training session is critical.

Second, student involvement in all aspects of the process is not only beneficial, but can also serve as a motivating factor. Asking students to help identify effective embeddedness strategies, debate the appropriateness of particular modes for particular topics, and design the multimodal tasks and evaluations are all ways to get students involved in the process.

Finally, students seem to gain increased benefit from multiple experiences with these tasks. The first products students create may not immediately lead to improved conceptual understanding, but being patient and letting them continue to try may be the key to success. Explore the different ways you can set up these activities so you can discover the best way to use multimodal writing tasks in your classroom. ■

Mark McDermott (mark.mcdermott@wartburg.edu), *a former high school science teacher, is an assistant professor of science education at Wartburg College in Waverly, Iowa.*

FIGURE 4

Sample multimodal tasks for students.

- Create a magazine article for a high school journalism class discussing the structure of the atom, the periodic table of the elements, and the relationship between the two.
- Write a letter to your parents describing a week in the life of a cellular organelle.
- Develop a travel brochure describing a famous volcano and how it works.
- Publish a newspaper article about how recycling works in your school and what happens to the recycled material.
- Make a cartoon for a third-grade class explaining how Newton's laws impact their everyday life.

On the web

Sample embeddedness assessment rubric: *www.nsta.org/highschool/connections.aspx*

References

Galbraith, D., and M. Torrance. 1999. *Knowing what to write: Conceptual processes in text production*. Amsterdam: Amsterdam University Press.

Gunel, M., B. Hand, and S. Gunduz. 2006. Comparing student understanding of quantum physics when embedding multimodal representations into two different writing formats: Presentation format versus summary report format. *Science Education* 90 (6): 1092–1112.

Gunel, M., B. Hand, and M. McDermott 2009. Writing for different audiences: Effects on high school students' conceptual understanding of biology. *Learning and Instruction* 19 (4): 354–367.

Norris, S.P., and L.M. Phillips. 2003. How literacy in its fundamental sense is central to science literacy. *Science Education* 87 (2): 224–240.

Prain, V. 2006. Learning from writing in secondary science: Some theoretical and practical implications. *International Journal of Science Education* 28 (2): 179–201.

Prain, V., and B. Hand. 1996. Writing and learning in secondary science: Rethinking practices. *Teacher and Teacher Education* 12: 609–626.

Wallace, C., B. Hand, and V. Prain. 2004. *Writing and learning in the science classroom*. Dordrecht, The Netherlands: Kluwer Academic Press.

Yore, L., G. Bisanz, and B. Hand. 2003. Examining the literacy component of science literacy: 25 years of language and science research. *International Journal of Science Education* 25: 689–725.

Yore, L., and D. Treagust. 2006. Current realities and future possibilities: Language and science literacy—empowering research and informing instruction. *International Journal of Science Education* 28 (2): 291–314.