Writing and Science

An interview with Michael Strauss

WT: In recent years there has been an increased emphasis on integrating writing with other disciplines. As a science educator, do you think there is a place for writing in science class?

Strauss: I can't imagine a science class without writing! Children learn the most by thinking about what they are doing. And one of the very best ways of thinking is writing. What I mean here is writing "Writ Large," which includes drawing pictures, making diagrams, writing numbers, and making lists **as well as** writing sentences and paragraphs.

I believe the very essence of learning is doing and redoing whatever it is we are trying to learn. And in the context of a science class, this means not only doing and redoing experiments, observing, drawing conclusions, talking and reading, but putting thoughts about all this on a page, in words, pictures, and numbers. This takes children's thoughts out of their heads and places them in front of their eyes so they can see what they understand and what they don't. And then rewriting and redrawing, a revision of thought, can occur. This is the very essence of learning, isn't it?

If you think about it for a moment, you'll realize this is what real scientists are doing in their lab books and field notebooks, and in the research papers and books that they publish from those notebooks. The papers and books are just amplifications and revisions of original observations and thoughts written first in the laboratory or in the field. It's how knowledge about the world is created. So I believe that's what children really should be doing in science class.

WT: What kind of writing activities should teachers use? Why are these activities appropriate?

Strauss: Using writing as a **tool** for learning science should be primary. Better writing skills will evolve the more children write. In the beginning, the most useful writing activities are those which allow children to write about their own observations and thoughts, in their own language, in their own way, without fear of immediate judgment. I don't mean to say there should be no guidance or direction, or that some kind of evaluation shouldn't eventually occur. But writing "correct" answers or observations in preformed blanks and boxes on a workbook page is much less helpful in learning how science is really done. It becomes less interesting and too focused on the "right" answer. It doesn't allow for much thinking about the meaning of what is being written. And if it's evaluated too soon, it kills interest in what science is. At the university level, that kind of laboratory experience is called "cookbook science." It's too artificial.

If students can help design the experiments, draw the boxes, graphs and tables, the objects and apparatus, and can write their own descriptions, there is more personal investment in what is happening. All of this is what I would call "Writing Writ Large." It's the best way to begin. That initial effort can be recast in more formal and organized ways later, if that is desired. And that's when evaluation can happen. And the

teacher can focus and guide children through various stages of writing with the content in mind, as it evolves from initial personal observations, descriptions, rough notes, and jottings to more formal ways of representing things. In this way students can come to learn that all kinds of writing, as well as rewriting and revision, is not just what happens in science class. It's what professional scientists do as well. It's how science happens! It's how their science book was written.

It is too often the case that science is thought of only as a body of facts, collected in textbooks, films, CD-Roms, and in libraries. And by reading and memorizing it one can become proficient in it. Well, it is indeed such a thing, and reading about it can make one more knowledgeable about it. But two things aren't obvious to children (and many adults as well): 1) It had to be established—there is a process by which it comes to be, and 2) It is still changing—the process is still ongoing. Activities involving informal writing "Writ Large," followed by revising, recasting, and redrawing, all of which involve **rethinking**, provide an understanding of the process by which science really happens. And that is just as important as understanding the presently accepted body of knowledge —the facts.

WT: What are the benefits—in science and in writing—of integrating writing with science?

Strauss: I think my answers to your first two questions indicate I believe science is inextricably linked to writing. There really is no such thing as science without it. What can happen in science class—the revision of thought, the reworking and recasting of ideas that leads to an understanding and knowledge of science—is exactly analogous to what happens in the process of learning to write. So I believe that understanding how to learn science and how to learn to write are complementary to each other. They come together naturally.

Think about what might happen in a typical science class. First there might be some reading, discussion, and thinking about an experiment to be done to support a theory, or maybe it's an experiment just to explore and see what happens. There could be writing during the planning. What's the best way to do it, what will it mean, and what possible results might occur (predictions)? Then it must be carried out, and perhaps done again because it didn't work the first time (a container broke, a solution spilled, or the seeds didn't sprout). Students must observe and make measurements, try different techniques and methods, try alternatives, and they must write down what they are doing, what they observe, perhaps drawing a picture of what they see or the apparatus they have made.

Later, perhaps the next day or following week, the descriptions, observations, and diagrams can be connected to a rough written explanation of what occurred, why things happened the way they did. And of course this leads to a rough written conclusion. All of this will probably involve going back to the notebook data and jottings as the thoughts and ideas evolve and are expressed in writing. There would have to be rereading and rethinking, about what's in the textbook, about the observations written down during the experiment. Writing is the tool by which everything is done. This is learning science. But it is also learning how to write, how to express ideas clearly.

So it seems to me that writing and science could easily be integrated in school. The separation of writing from the content areas is an artificial one, of course. History, social studies, biology, chemistry, all involve writing. Open a text. There it is.

Of course writing "Writ Large" is more important when we are talking about subjects where the symbols aren't just words (chemistry, mathematics, biology, etc.). But really, having writing class and chemistry class in separate rooms with different teachers is just the way we have chosen to do things. If we like, we can choose a different way. Students can write about the chemistry they know, and the biology, and the mathematics. To be sure, their papers may have more diagrams, equations, and other symbols, but the quality of their thought will be expressed in the quality of what they write. And they can learn to become writers in any subject, including science.

WT: How do students usually respond to writing in science class?

Strauss: That depends on the kind of writing you ask them to do. If you consider short sentence answers to questions (fill in the blanks), or writing short paragraphs, multiple choice, true/false, and matching questions as writing in science, then you miss so much about what real science is about. Students may like using paper and pencil this way, but it is because they have to think much less about the content. It's easier for them. It's also easier for the teacher to grade.

If you are treating writing as an add-on to your regular content, trying to teach them to write in science class just by choosing a science topic, then you're missing the point. For example, you might ask them to read a section of the book, or to find an article in a popular science magazine or the newspaper, and write a brief summary of what they've read. It is often the case that the day before they hand it in, they will sit down with the text of the book or magazine open before them and will write a single draft of the paper (perhaps reading the text or magazine as they write) and turn it in the next day.

When the graded paper is handed back, it often goes into a desk drawer, never to be seen again. All your comments, suggestions, and corrections for that paper will never be used to make

it better. Even if you try the same assignment again with a different topic, the process will usually repeat itself. And you might get discouraged because the papers aren't done well at all. And perhaps you feel you really don't have time to use the process approach, involving multiple drafts. After all, you've got your content to teach. You're not a writing teacher! So you will be tempted to go back to "fill in the blank" answers based on text material, thinking that you haven't got the time to teach writing. You might then think that they should learn how to write only in English class, but you will miss so much if you do. Real science isn't fill in the blanks or short, descriptive paragraphs. It's a process, just like writing is a process!

WT: So if a science teacher wanted to use writing as a teaching tool for the first time, what suggestions would you offer? Where is a good place to start?

Strauss: It is essential to begin with informal, ungraded writing in a journal or lab notebook. You've got to get them started on the process of putting their thoughts out on the page. You can grade it simply by making sure they do it, rather than reading and commenting on it in great detail. At this stage, spelling, grammar, and punctuation are not important. Getting ideas on paper, in words, pictures, and numbers is.

An easy way of starting is to end a class by having students write a five-minute summary of what they have heard, seen, or thought about the content of the hour—e.g., an experiment on acids and bases, a film on stars, a class discussion or experiment on dissecting a frog. Or you can begin the class by having them write a five-minute summary of what occurred during the previous class. You can stop in the middle of class and have them write about how they might solve a particular problem, explain a phenomenon to their parents, recast what has just been said in a discussion, describe an observation they have made, etc. All of these short, quick, and informal pieces might be collected together in a journal or notebook. You can collect the notebooks to make sure they are participating, but you need not read everything in detail.

"Real science isn't fill in the blanks or short, descriptive paragraphs. It's a process, just like writing is a process!"

Once informal writing has been accepted as a normal part of what happens in class, it can serve as the nucleus for more extensive efforts, as I described above, in designing, performing, and reporting on an experiment. Or you might ask students to look through their short, informal writing and select one piece to elaborate into a full page: "Go back to the journal entries you wrote when we were learning about cells (sedimentary rocks, rusting, the water cycle, etc.), and pick one to elaborate into a full page." This could be followed by a short first draft which they could share with each other, comment on, and then rewrite before handing in.

The sequence from informal to formal writing is the key. There are literally hundreds of ways to do this in teaching science class. A number of texts provide excellent ideas. Though not focused particularly on science, Toby Fulwiler's *Teaching with Writing* text is particularly useful for the upper grades (5-8).

In learning chemistry, for example, students can do some simple experiments and then draw and write about what they have done, prompted by key questions about what they have experienced and how it might be explained. Consider the process of dissolving sugar and/or salt in water, for example (or you could consider other processes like evaporation of water, or mixing water and oil, or freezing water).

After simple experiments, students can be asked to write about them. Why might hot water dissolve sugar faster than cold water? Why might it dissolve more sugar than cold water? Can you help explain this with a diagram or picture? How would you design an experiment, using hot and cold water from the faucet, to prove that hot water dissolves more sugar than cold water? Draw a picture of how this would work. Make a list of the things you know dissolve in water (soluble things) and another list of things you know do not dissolve in water (insoluble things). Write about what all soluble things have in common and what all insoluble things have in common. They could share and discuss their writing on these questions in small groups, and then the whole class, with the teacher as guide, could discuss them. Explanations can be posed and conclusions can be drawn. And more formal writing can follow if desired. These examples are taken from my upcoming book, *Where Puddles Go: Exploring Physical Change.* In that text, I show how writing and science can be integrated in the process of learning both.

Similar writing and drawing exercises can be generated for any kind of science content. Along with more informal, short summary writings at the beginning and end of class, simple

writing assignments like these are a very good place to start, if you are a science teacher wishing to use writing as a teaching tool for the first time.

In my chemistry classes at The University of Vermont, I use a variety of writing assignments. Those vary depending on the size of the class (10 to 250). In small classes, I have students write summaries at the beginning and end of class, often involving chemical problems and ways of solving these. These are sometimes shared with the class as a whole using the overhead projector. Often we do this with five or six students at the blackboard and an equal number writing while seated, working on a particular problem and discussing ways of solving it.

In very large classes, I have a box near the exit to the room where students deposit anonymous pieces of writing about the course content—questions, concerns, interpretations. I make these into transparencies. These are then shared with the whole class, where we discuss and elaborate those points of concern during the next lecture hour. The writing is, of course, not graded (it's anonymous, remember), but it engages students in the content, both the writer and her or his colleagues. Such writing expresses the students' own concerns about the chemistry, in their own language, about what they really **want** to know. And often the writing itself leads to insights for the writer, which they share with me, and which I then share with all the students. Again, you see, the process of learning becomes a part of the content. All the students in the class can see this—the process, the insights, **and** the content.

WT: What cautions would you give to teachers who want to include writing activities in science lessons?

Strauss: Go slowly! Do what is comfortable for you and find out what works in your classroom. Don't try to do too many things at once. Don't grade the writing in the beginning, other than to require that it be done. Find out where and how writing can help you teach your content. Each class and each teacher is different. Don't try to institute a predesigned program. Look at the *Teaching with Writing* text, and see what looks interesting to you. You can help children learn to become better writers, but you also want them to learn the subject.

Add a short, informal writing exercise in a journal or notebook and see what happens. Let more formal writing assignments follow from that in a fashion which fits what you are teaching. If you change too many things too fast, your students will rebel. And you don't want to wind up teaching writing and less science. Your primary effort should be to teach science using writing as a tool. Students will become better writers because they are writing more. If you compromise your content just to get writing into your class, you're not teaching science with writing, you're teaching writing at the expense of the science content.

> *"Doing science really is doing writing. There would be no science without it."*

WT: What closing comments do you have for our readers?

Strauss: Writing is much more than just correct spelling, grammar, punctuation, and well constructed sentences and paragraphs. It is thought, frozen in time on a page—in whatever kind of symbol system we choose to use. In that frozen form we can hold it in front of us, see what we think, what we mean, and how we might change our thoughts and write them down again. Understanding how this process works is the essence of learning in school and in life. Integrating writing and science in the science classroom is a very good way to help children come to such an understanding. Doing science really is doing writing. There would be no science without it.

Michael J. Strauss is Professor in the Department of Chemistry at The University of Vermont. His publications include "Interactive Writing and Learning Chemistry" and "Writing to Learn in Large Lecture Classes," both co-written with Toby Fulwiler and published in the Journal of College Science Teaching*; "Writing and Thinking in the Physical Sciences," a chapter in* A Community of Voices *(Macmillan, 1992); and* Where Puddles Go: Exploring Physical Change *(Heinemann, due August, 1995). Dr. Strauss has presented numerous grade-school and high-school workshops.*