AN EXERCISE IN THINKING, WRITING, AND REWRITING

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Science teachers often complain about their students' thinking and writing, but often don't know what to do to improve them. Here I describe an exercise that addresses both challenges at once with first year university students in a special program.

Early in a year-long interdisciplinary program that includes all sciences, I assigned an article in the current primary literature (Schwenk, K. 1994. Why snakes have forked tongues. *Science* 263:1573-1577). In the same week, we asked a simple question in tutorial. *"Could a bacterium of a given size sense a concentration gradient with different parts of its body at the same time, or would it need a memory? Can gradients be that steep?"* The problem is difficult and its answer is interesting. I won't bother you with those details here; my point is about the form of the work, not its content. I asked students to write a paper on the general problems of using information to guide movement; not just by snakes or bacteria, but by any mobile animal. Other well-formed, sufficiently open and challenging problems would serve as well. Each author was also assigned first and second editorship of two other students' papers; everyone got 3 grades for the exercise.

A secretary date-stamped the submitted papers and gave them to the first editors. The student editors inserted comments and wrote essays about the authors' conceptual approach, much as scientists do in reviewing papers for journals. (Most editors had to interview the authors to be clear enough to respond effectively, which was revealing.) Editors also rewrote authors' papers for them; what they thought authors would have written had they expressed more clearly what they were thinking. Authors re-wrote their papers, second editors reviewed and rewrote them again, and then the authors produced final drafts and handed them all to me.

In one night, I commented on the evolution of 65 papers but judged the quality of only the final drafts. I judged authors' receptiveness to insightful feedback, and commented at length if editors missed anything important or if ideas were so interesting that I couldn't resist. In both grading and commenting, I stressed the effectiveness of the author-editor collaborations in clarifying and strengthening scientific arguments, and the willingness of editors to serve authors when editing and not just themselves.

Final drafts were readable, enjoyable, and revealing, and papers became more distinct from each other as they progressed through the drafting. The exercise was a monument to editors, authors, and the community of scholarship we were building. It was an enjoyable evening's work for me and a lot of fun and challenges for everyone. Best of all, the students *demanded* to do a similar exercise the next term. Science had become part of their lives, and they loved it. (They learned a lot, too.) ■

Author's Note: For more on my general approach to teaching, which emphasizes the development of creativity in students, see (Gass, C.L. 1998. Teaching for creativity: an example. *CDT Link*, Centre for Development of Teaching and Learning, National University of Singapore. July 1998 and Gass, C. L. 2002. Introduction to the special feature: educating for integration and sustainability. Conservation Ecology 5(2): 31. http://www.consecol.org/vol5/iss2/art31). For a description of the special program, see Benbasat, J. A. and C. L. Gass. 2002. Reflections on integration, interaction, and community: the Science One program and beyond. Conservation Ecology 5(2): 26. http://www.consecol.org/vol5/iss2/art26).

Ideas that Promote Active Learning

ECOLOGICAL ISSUES PRESENTATION & REPORT

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A group project can be effective in helping students understand more about complex issues—and appreciate that most do not have one easy solution. The focus in my course is generally ecological and biotechnological issues in the news, but the project I use can be tailored to many other debated fields. Each group picks an issue to research, then presents two *different* viewpoints. Often, this is done as a pro/con type presentation. But sometimes students choose to present the government's viewpoint, industry's viewpoint, consumers' viewpoints, the media's viewpoint, etc. Other times, the students present the problem, and then present 2–3 different ways to solve the problem. I try to encourage students to present the side which they agree with the least. This helps them to appreciate multiple points of view.

This project is useful for science majors and non-majors alike. For science majors, the issues I focus on are

- not having an *a priori* conclusion, but researching all available data.
- understanding that emotional and political arguments need to be taken into account when applying scientific discoveries to real-world applications.

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