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ABSTRACT

As composition teachers work to develop process approaches to writing instruction, science teachers work to develop strategies for teaching science as a process of inquiry. In continuing efforts to revitalize science education, teachers use writing as a tool of inquiry. Exploratory writing, written field observations, close description, and written discussions, among other activities, are essential components of scientific inquiry. Just as science teachers have benefited from research on the writing process, writing teachers in the discipline can benefit from recent advancements in the theory and practice of teaching science as a process of inquiry. This paper first describes the traditional approach to science education, an approach that, while emphasizing the transmission of factual data, often tends to devalue the broader roles of writing as a tool for scientific inquiry. Next, the paper identifies theoretical assumptions that, in contrast to traditional principles, inform current efforts to teach science as inquiry. Finally, to illustrate how teaching science as a process of inquiry utilizes writing, the paper describes selected writing projects of effective teachers in general education courses. It contends that without effective writing instruction in the sciences and social sciences, students cannot master a full range of composition skills. (Contains 24 references.) (NKA)

Linking Writing to the Process of Scientific Inquiry: Strategies from Writing Teachers in the Disciplines

By

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Paper presented at the Annual Meeting of the Conference on College Composition and Communication (51st, Minneapolis, MN, April 12-15, 2000)

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Linking Writing to the Process of Scientific Inquiry: Strategies from Writing Teachers in the Disciplines

As composition teachers work to develop process approaches to writing instruction, science teachers work to develop strategies for teaching science as a process of inquiry. This ongoing movement in science education emphasizes creativity and invention in an open-ended process fundamentally different from more static conceptions of "the scientific method" as a rigidly formulaic "recipe" for gathering factual data, the raw material of scientific knowledge. In continuing efforts to revitalize science education, teachers use writing as a tool of inquiry. Exploratory writing, written field observations, close description, and written discussions, among other activities, are essential components of scientific inquiry. Just as science teachers have benefited from research on the writing process, writing teachers in the disciplines can benefit from recent advancements in the theory and practice of teaching science as a process of inquiry.

In this essay, we first describe the traditional approach to science education, an approach that, while emphasizing the transmission of factual data, often tends to devalue the broader roles of writing as a tool for scientific inquiry. Next, we identify theoretical assumptions that, in contrast to traditional principles, inform current efforts to teach science as inquiry. Finally, to illustrate how teaching science as a process of inquiry utilizes writing, we describe selected writing projects of effective teachers in general education courses.

Educational researchers recognize that the way science was taught in the United States changed little during the twentieth century. Prompted by the Cold War, America's National Science Foundation disseminated a series of "new" curricula that perpetuated an "empirical-inductivist" approach to teaching science, an approach that emphasizes formal logic in generating, confirming, and interpreting the facts of science (Duschl, 1985). After the Soviet Union launched Sputnik in 1957, Congress passed the National Defense Education Act. Admiral Hyman Rickover (1959) declared the spirit of this act succintly: "The education process must be one of collecting factual knowledge to the limit of the learner's capacity. . . . Nothing can make it fun" (p. 61). This approach of Rickover and the National Science Foundation, reducing science to the production and transmission of "facts," diminishes the importance of curiosity, creativity, and critical inquiry among students. While this traditional approach utilizes writing to report data, it tends to devalue writing as a tool for thinking, a tool for describing phenomena, exploring problems, developing explanations, speculating on possible causes.

In many American classrooms, learning science still means learning facts. In 1997, John Eichinger surveyed college students regarding their high-school science courses. Writing for the journal *School Science and Mathematics*, Eichinger reports that both science majors and non-science majors "were in relative agreement that traditional instructional methods (e.g., textbooks, quizzes/tests, lectures, memorization, worksheets, and other [such] written work) continue to predominate in secondary science education" (p. 128). These findings support earlier work of J. J. Gallagher, who, writing in the journal *Science Education* (1991), concludes that science instruction often over-emphasizes textbook learning and the transmission of factual data that the student must either restate or, perhaps more often, identify accurately from among the options A through E of multiple-choice tests. Gallagher warns that "as scientific knowledge has grown in recent decades . . . textbooks have grown by accretion," authors often failing to "prune out" existing passages to make room for "new knowledge" (p. 122). Similarly, Randy Moore, writing for the *Journal of College Science Teaching* (1994), argues that during the early 1990s, "under increasing pressure to educate more underprepared students," universities "resorted to memorization-based courses based on lectures, followed by fill-in-the-blank and multiple-choice exams" (p. 289).

Moore, Dean of Arts and Sciences at the University of Akron, argues further that in "today's multiple-choice age" students write seldom and, when they do write, often complete "mechanical and trivial" assignments (p. 289). Our experiences tend to confirm Moore's observations: textbook readings, lectures, and examinations of factual recall dominate many science courses in college general education programs. In 1998, Linda taught laboratory sections of the Human Biology course at a major research university distinguished by its strong commitment both to writing and to undergraduate education. Twice each week, 350 first-year students gathered to hear the professor lecture. Three times a semester, students sat for a multiple-choice exam on the lectures *and* readings from the course textbook. During this semester-long course, students wrote only lecture and lab notes until 1999, when, at the behest of a dean, the course began to require one lab report written in essay form.

Such reductive approaches to teaching writing in the sciences persist; however, in 1996 the National Academy of Sciences published a set of educational standards for teaching scientific literacy in general education programs, standards that oppose mere transmission of factual information and re-emphasize enduring civic benefits of teaching scientific inquiry. According to the Academy's instructional goals, all students should be able to participate in public discussion on "scientific issues underlying national and local decisions"; further, students "should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it." And, significantly for writing teachers, "scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments" (*National Science Education Standards*, 1996, p. 22). To achieve these goals, the Academy insists that "Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating scientific arguments" (*Standards*, 1996, p.105). In summary, the Academy of Sciences insists that teachers must balance reading with hands-on, problem-solving activities to help students learn science as a process of inquiry.

The National Academy of Sciences urges teachers to emphasize writing as a tool of thinking. Rather than merely giving "a correct answer," students should write "using evidence and strategies for developing and revising an explanation"; groups of students should analyze and synthesize data and defend their conclusions; students should communicate their ideas publicly. With these general guidelines, the Academy recapitulates for science teachers specific recommendations of composition theorists who have developed strategies for writing as inquiry.

In his analysis of *Research on Written Composition* (1986), George Hillocks recommends inquiry as the focus of much effective writing instruction. He argues that writing has become a necessary tool for thinking about complex questions and that the process of inquiry prompts students to learn and practice appropriate writing strategies. According to Hillocks and his research associates, writing instruction focusing on inquiry presents "students with sets of data" or requires students to "find data" and helps these novice writers "develop skills or strategies for dealing with the data in order to say or write something about it" (p. 211).

In research of special interest to science teachers, Hillocks has found that "students involved in observational activities increase the level of specificity" in their writing "and are deemed more creative" (1979, p.34). In this study, he asked students to write detailed descriptions of things or events; that is, students practiced empirical observation and description, fundamental tools of scientific inquiry.

Applying the educational principles of both Hillocks and the National Academy of Sciences, we have developed the following example, a learning activity designed to give students structured practice in the process of inquiry as they explore the biological concept of species adaptation.

1. Ask students to collect beetles for a classroom terrarium. When a student has captured a beetle, he or she must write a well-developed, detailed description of the place where the insect was found.
2. After your students have collected two or three species--a click beetle, June bug, and pincher beetle, for example--ask individual students to observe one of the beetles closely. Each student will draw it in detail, label its major body parts--head and mandibles, thorax, abdomen, wings, and legs. Then, the student will write a very detailed description of the beetle at rest and in motion.
3. Place students into small discussion groups. Let them read their descriptions to their classmates. Then, ask students to read descriptions of the beetles' habitats and discuss how physical attributes--for example, the June bug's wings, the click beetle's leaping mechanism, and the pincher beetle's jaws--might help the insects survive in their habitats.

4. After group discussion, individual students revise their descriptions by focusing more directly on physical characteristics that help the beetle live in its habitat. Groups can present and defend tentative explanations.

As students complete this "hands-on" activity, they revise their observational writing, transforming it into a rudimentary scientific essay. There are many variations of this observational activity: descriptions of leaves, of fish in home aquariums, of domesticated animals, of animals in a zoo or museum may be developed into essays.

To conclude, we offer two further examples of how teachers link writing to inquiry, one learning experience devised and tested by Peter Whelan, Professor of Geology, and the second by Dawn Braithewaite, Professor of Speech Communication. Both professors were faculty members at the University of Minnesota, Morris, a small liberal-arts campus.

In the syllabus to his Mineralogy and Crystallography course, Whelan writes,

> . . . as part of this class I urge you to keep a journal or log book in which you record a variety of data, information, observations . . . . I am encouraging this activity in the growing belief that our ability to learn and to work with any material (geological or otherwise) is enhanced by our taking (or being given) time to put our thoughts, reflections, observations into words.

So Whelan's students write descriptions detailing the complex structures of minerals and crystals in stasis and in formation. Rather than merely reading about these structural properties and then identifying them in laboratory samples, the students first write descriptions of those intricate structures and then compare their written descriptions. Finally, the students check their own written descriptions against those found in the textbook before reading about the morphology of the crystals.

In his general education course in introductory geology, Whelan uses an intriguing variation of this observation-description-comparison teaching strategy. He schedules "happenings and events," activities that sometimes help his students use writing as a vehicle for applying observational skills to learning in other disciplines. For example, he once asked his students to view the mixed media prints of an artist, write descriptions of the works, and then write close descriptions of their reactions, thus applying strategies for writing observation and description to self-examination. "Did you sense any connections between the subject matter of the prints and geology?" Whelan asked his students.

Finally, we summarize how Prof. Braithwaite, in her course on interpersonal communication, links reading and writing to a process of social scientific inquiry. Braithwaite asks her students each to search popular periodicals for an advice article on a subject of interest. For example, a student may find an article with "tips" for improving a marriage or saving money or developing skills as a conversationalist. After summarizing the author's advice and arguments supporting it, Braithwaite's students must "test the author's advice in the 'real world'." Each student must compose a questionnaire to challenge the writer's conclusions, and with the questionnaire survey ten people. For example, a student may challenge an author's advice on teen-communication with a survey asking parents to describe effective practices that they and their teenagers use when communicating well. After thus testing the published author's advice, each student writes a paper evaluating the article with the student's own arguments based on results of his or her survey. Completing Braithwaite's reading-writing project, students generate their own sets of data as bases for reading critically not only the advice articles but also the course textbook.

As the above lessons in biology, geology, and social science show, student writing in the sciences and social sciences must vary according to the disparate modes of inquiry proper to each discipline. We emphasize that by linking writing to inquiry, science and social science teachers act as very effective writing teachers. Indeed, we feel that without effective writing instruction in the sciences and social sciences, students cannot master a full range of composition skills.

Castleton, Vermont, 2001

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