

Writing and Science

Composing Dialogues for Critical Thinking

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Few contemporary scientific texts are written in the dialogue form used by earlier scientists such as Newton, Galileo and Boyle; additionally, the extended form of dialogue that exists in professional journals is usually not visible to the novice student. Therefore, students often are not actively engaged in the language and rhetoric of science. As Jay Lemke points out in his book *Talking Science: Language, Learning, and Values*: “Talking science is not the totality of doing science. But very little science gets done, or could get done, without the semantic resources of language, and particularly the thematic patterns and genre structures specific to science.”[1] Exploring the resources of dialogue in scientific argument improves student understanding and skills in both science and language.

In their essay “Dialogue as Data,” Kathleen Hogan and Joellen Fisherkeller summarize four phases of scientific inquiry: forming questions and hypotheses; designing investigations and generating data; interpreting data and integrating information; and finally, building and communicating arguments. It is in this last phase, often neglected in traditional science education, that writing can be particularly helpful. According to Hogan and Fisherkeller, this stage of inquiry teaches students to “. . . persuade a community of peers of the validity and significance of scientific findings; [and to] use critical response skills to judge, evaluate, and defend knowledge claims.”[2] Explicitly pursuing this phase of inquiry can help students broaden their concept of science. In addition, non-science majors can be more readily engaged in the ideas and practices of science through the process of building and communicating arguments. General students will identify with the logic and drama of dialogue even before they have a thorough grounding in the scientific content.

The project described below is a collaborative writing assignment designed for a team-taught interdisciplinary course for junior and senior undergraduate students representing a variety of science and non-science academic majors. In addition to offering an opportunity for assessing science understanding, this project supports particularly well the development of voice, the strengthening of peer response and collaborative processes, and the growth of critical thinking skills.

Teaching Context

This assignment was designed for the writing-centered course “The Literature of Natural Science” at Willamette University, a private four-year liberal arts institution in Salem, Oregon. Willamette is home to 2500 students, 1860 of whom are undergraduates; the remainder are in graduate programs in law, administration, or education. In the College of Liberal Arts, the student-faculty ratio is 11:1, and writing-centered classes average 15–20 students. “The Literature of Natural Science” fulfills one of four writing-centered requirements for Willamette students and is designed especially for upper-division students who have already completed their general education requirements in natural science and literature.

We set about exploring the nature of scientific communication with a group of upper-level undergraduates. Our plan included both an historical and a contemporary component: We read “classics” of science such as Galileo’s *Dialogue*, Newton’s *Principia* and Darwin’s *Origin of Species* along with papers on DNA and Plate Tectonics. While our primary goal was to subject a group of primary scientific texts to literary and rhetorical analysis, we also searched for comparisons and links between the historic and contemporary texts. For all the texts, we explored how the authors used conventions of discourse, stylistic and literary devices, and structure as argumentative tools.

We also expected the students to bridge the divide between science and the humanities. The dialogue assignment is an ideal device toward this end. Science majors understand the concepts underlying a scientific issue and bring a facility with mathematical language and visual representations of data, while humanities students appreciate the use of metaphor and its function and can analyze structure, voice, and persuasive devices. The assignment encourages students, working in small groups, to teach each other in order to create a cohesive and compelling dialogue. Thus, the dialogue assignment is an explicit attempt to meet one of the goals of the course, to have the students think on both sides of the divide. In fact, some students were so taken with the possibilities of the dialogue that they chose to write their final research papers for the course in the dialogue form.

Because this was a writing-centered course, we had an obligation to include in our work certain writing activities, such as informal writing, peer editing, multiple-drafts, and writing to learn. The dialogue assignment addressed several of the writing goals. The unusual form required the students to be conscious of the writing process and to pay attention to the rhetorical devices employed in their argument. For most students, the draft of the dialogue was a writing to learn experience as they articulated a position through the voice of a character. Peer editing and revision are natural and necessary consequences of group writing, so the dialogue assignment served us well from both a process and a content perspective.

Dialogue Assignment

As the second formal writing assignment in “The Literature of Natural Science” we asked students to work in groups to create a dialogue about a selected controversial topic. With this assignment we hoped to develop awareness of rhetorical and argumentative strategies in scientific texts, to expose students to a contemporary scientific issue, and to create an opportunity for successful collaborative writing.

When the students began this assignment, they had already read Galileo’s *Dialogue Concerning the Two Chief World Systems* and Robert Boyle’s *The Sceptical Chymist*. The dialogues were chosen as the first scientific readings because they are first chronologically and because the form is more accessible to students than contemporary scientific genres. Galileo’s *Dialogue* was particularly instructive with his descriptions of

observations and experiments, and his use of believable characterizations. Science students and humanities students clearly read the texts differently; science students tended to look immediately and almost exclusively to content, while the humanities students looked to style to find meaning. In classroom discussions, the students helped each other to understand how style and content reinforce each other to construct a larger meaning. The texts therefore became more comprehensible to all students. Classroom discussions also included the philosophical, historical and political contexts of Galileo and Boyle, the scientific import of the works, and the relative success of the rhetorical techniques they employed. The dialogue assignment thus helped make scientific ideas accessible to humanities students and clearly put science within an historical and social context for scientists.

The interchanges between students, tentative at first, became lively discussions as the students learned to communicate. They discussed the use of setting and character in dialogue, the incorporation of evidence of various kinds, the use of examples from common experience, the use of metaphor and expressive language, and other rhetorical strategies in the classic texts. These readings and discussions provided examples of techniques that students could then apply in creating their own dialogues.

Once we had studied the dialogue form sufficiently to establish some patterns and expectations, we next introduced the contemporary scientific issue which would provide the content for the students' own dialogues. We tried to choose a controversial issue that would naturally bring the students to their work with a variety of viewpoints. In our most recent version of the course we focused on the Human Genome Project and gene patenting. We used short articles from *Science* and *The New Yorker*, and information from the web site of the National Human Genome Research Institute to introduce students to the topic. Here is the preliminary assignment description:

The general topic for your dialogues is "Patenting the Human Genome." We have given you several readings to begin your thinking on this issue. You may wish to do more research to contribute to your dialogue; remember, however, that our aim is not for you to come to a full and distinct understanding of the issue, but to experiment with ways of using dialogue as a form to explore controversial issues in science.

Groups will meet in the Writing Center classroom to draft your dialogues in a group writing program called *Aspects*. You should have done your preliminary reading before these drafting sessions, and it might help to have some idea, at least individually, about what kind of character you would like to represent in the dialogue.

Below are some criteria we will use in evaluating your polished dialogues. These are meant to be suggestive and illustrative, not exhaustive; you may have additional creative ideas about content and format. You should, however, give some thought to each of these categories:

Use of characters: definition of character and role; consistency of the personality, assumptions, theoretical position of each character.

Setting: If you wish, you may set the scene to some degree through the dialogue; where are we? who are we?

Variety of argumentative techniques: examples and anecdotes; "thought experiments"; data from article or elsewhere; mathematics or statistics; deductive logic. . . . etc.

Variety of persuasive techniques: emotional content, figures of speech, links to common experience, appeal to other authorities, use of character movement to encourage reader movement in ideas. etc.

Written expression: mechanical accuracy and elegant choice of language are essential; try to make good use of the dialogue potential by developing a distinct voice for each character; exploit the figurative potential of the language as appropriate.

Audience awareness: the dialogue should be accessible to the inexpert audience; you might imagine some critical audience such as Galileo faced, if you want to make things more challenging!

Overall organization: Your exposition should take advantage of the non-linear potential of dialogue structure; points can be woven together in a flexible fashion, the movement of the dialogue can even surprise the reader on occasion or be interrupted by physical realities of the setting in which the dialogue takes place.

Conclusion: you should reach some tentative resolution of the issues you consider in your dialogue

Along with the completed dialogue, each member of the group should turn in a **one-page self-reflection** on the process of creating the dialogue. What things worked well in developing the dialogue? What was most difficult? What were the steps in your process? What did you learn from it? How would you characterize your own contribution to the group? How would you describe the process of the group?

We assigned students in groups of four, striving for some balance between science and humanities students in each group. Please note that we began our group work with a software program called *Aspects*.^[3] This program supports collaborative writing artfully, and though it is not necessary to the project, it does provide interesting learning opportunities. Students used *Aspects* in a networked Macintosh classroom where they were able to work simultaneously on the same document while having a chatbox open on the screen to support and retain conversation around the document. Students responded differently to this experience; some found it exciting and reported ^[4] positive results from *Aspects*:

It really gave us a good feel for what issues were going to be important to us and what we needed to learn more about.

The Chatbox really got the dialogue flowing between us. . . . We were all able to raise issues that weren't readily apparent to the other parties. We were also able to incorporate the ideas that were important to each specific member without sacrificing the "group" structure within which we were working.

It was easy for people to get their thoughts down without having to wait. If you saw a point you wanted to respond to, you could do it right away. We were able to get more substantive material using this method.

Others preferred to use more conventional methods of creating their dialogues such as working on a single computer in a round-robin fashion, tape-recording and transcribing their dialogue, or drafting individually and integrating their work. Whatever method a group used, they reported positive learning about writing, voice, revision, collaboration,

argumentation, and critical thinking through developing the dialogues:

I think that we've each learned much about our individual writing styles and personalities. By writing in [character] voices similar to our own, we explored different ways of presenting or arguing a point.

Revising posed an interesting challenge because if we changed one argument, often the entire dialogue was affected.

Writing the dialogue was rewarding because it required us to utilize various forms of persuasion. I tend to rely most heavily on logic and statistical data. I enjoyed learning how to employ other persuasive techniques.

Overall, I think I learned to be less shy about my writing and to not worry so much about being perfect.

Developing a voice is one of the most difficult things for me to do in my writing and I think that this assignment forced me to focus on that aspect of the writing process.

[For revision] what worked best was going through the dialogue page by page, rearranging the arguments, taking out unnecessary or repetitive comment, and adding statements where necessary.

I learned that one has to approach dialogue with an open mind if one wants the other sides to be objective and open.

I actually learned a great deal about the Human Genome Project and the patenting process, both of which I had little knowledge about prior to the assignment.

While our particular assignment is concerned with readings and issues in the sciences, similar assignments could easily be structured in other areas of inquiry. Colleagues in our own institution have success with various forms of dialogue in the departments of Politics, Philosophy, History, and various cross-disciplinary courses. In this assignment it is crucial to provide some model of literary, journalistic, or documentary dialogue so that students begin their work with a sense of the possibilities of form.[5] Dialogue is an especially exciting rhetorical pattern because it provides structured practice with collaborative writing and strengthens student practices of critical thinking by inviting them to consider alternative points of view, encouraging them to analyze assumptions of a position, and training them to perceive complexity and tolerate uncertainty.

Critical Context

The critical background for this assignment comes from studies of the dialogue as a literary and rhetorical form, from studies of student collaborative work, and from analysis of critical thinking skills.

The dialogue as a form is particularly suitable to support growth in writing that comes from working in a collaborative format. Such work makes clear the active and constructivist component of writing [6]; students see how audience affects tone and how different voices struggle to compromise with each other. For example, students working on the human genome dialogues found that they often disagreed about the worth and application of the scientific research they were discussing. Their disagreements drove

them deeper into their research so that they could present their opinions clearly in the dialogue, and they struggled to show how their arguments were formulated from scientific evidence. Likewise, they found that in the dialogue, a simple statement of scientific evidence was not enough; they needed to pay attention to the order, context, and style of presentation in order to be persuasive.

Although contemporary students find the formality of the classic dialogues odd, as they work with this assignment they discover the contemporary analogs of the dialogue form in the short story, radio, television and film. Students had the opportunity to present a reading of part of their dialogue to the class. Rather than imagining themselves in the comfortable garden setting of Galileo's characters, some of them envisioned a talk-show roundtable or a government hearing as the setting. They combined a familiar venue with the argumentative rigor of the classic dialogue.

The value of the historic texts in providing the model for these dialogues was considerable. The combination of story with exposition, of scientific content with familiar character types, was energizing for student readers. In addition, the discovery that some scientific "facts" had changed in the intervening centuries pointed to the contingent nature of scientific constructs. As the American Association for the Advancement of Science stated in its report *The Liberal Art of Science*, "The historical approach has a distinct advantage in that it does not require much initial scientific or sophisticated mathematical skill. This approach allows for the gradual development of a scientific knowledge base and science-related skills." [7] For the general student, the encounter with classic dialogues had a positive effect on scientific literacy as well as on writing skills.

Students working on this assignment also appeared to gain strength in all aspects of collaborative skills as described by Kris Bosworth in her article "Developing Collaborative Skills in College Students." [8] These include interpersonal skills, group building/management, inquiry skills, conflict resolution, and presentation. Depending on the goals of a particular course or instructor, these collaborative skills can be highlighted or de-emphasized. If these goals are central to the assignment, it would be useful to provide specific assessment of them through skills checklists such as those described by Sharon Farago Cramer in her essay "Assessing Effectiveness in the Collaborative Classroom." [9] Even if the development of collaborative skills is not a key goal of the assignment, some explicit attention to collaborative process is necessary to avoid delays and conflicts within the dialogue groups.

Key critical thinking skills are also developed in the dialogue assignment. The *Watson-Glaser Critical Thinking Appraisal* [10] defines critical thinking as a composite of five sub-abilities: the ability to define a problem; the ability to select pertinent information for the solution of a problem; the ability to recognize stated and unstated assumptions; the ability to formulate and select relevant and promising hypotheses; the ability to draw valid conclusions and judge the validity of inferences. We have found that developing a dialogue implicitly requires of students that they exercise and strengthen these skills. The analysis and writing of dialogue is particularly effective in helping students to discover overt and covert assumptions in their own and others' thinking. Developing the dialogue as a group requires students to focus on arguments from several points of view, thus uncovering their foundations. The dialogues also provide an incentive for identifying the most relevant information and give students practical experience in drawing conclusions and inferences.

As a means for learning about science or other disciplinary content, the dialogue is engaging and effective; perhaps it is even more effective as a tool for developing confidence and tenacity in writing. The dialogue assignment allows students to work on

aspects of persuasion, voice, revision, logic and inference in their writing in a situation where they are affectively invested in the material and are supported in their work by peers. As a means of developing skills in writing, collaboration, and critical thinking, the dialogue offers untapped opportunities in the classroom.

Notes

1 p. 122.

2 In Mintzes, Joel J., *etal.*, eds. *Assessing Science Understanding*, pp. 97–98.

3 This program is published by Group Technologies, Inc. in Arlington, VA.

4 Please note that all student comments in this article are taken from reflective writing completed in “The Literature of Natural Science” in Spring, 1999.

5 For an interesting study of dialogue in the nineteenth and twentieth centuries, see Michael Macovski’s *Dialogue and Literature: Apostrophe, Auditors, and the Collapse of Romantic Discourse*. A more specific study of Renaissance dialogue as it relates to Galileo can be found in Virginia Cox’s *The Renaissance dialogue: Literary dialogue in its social and political contexts, Castiglione to Galileo*.

6 For a brief and excellent summary of the constructivist view of collaborative writing based on work by Vygotsky, Smith and McGregor, see Jeanne Marcum Gerlach’s essay “Is This Collaboration?” in *Collaborative Learning: Underlying Processes and Effective Techniques* edited by Kris Bosworth and Sharon J. Hamilton, pp. 5–14.

7 p. 46.

8 p. 27 Bosworth and Hamilton, eds. *Collaborative Learning: Underlying Processes and Effective Techniques*.

9 pp. 69–81, Bosworth and Hamilton, eds.

10 See John E. McPeck, p. 23 ff., *Teaching Critical Thinking*, for a description of these skills and a discussion of opinions seeing critical thinking as a general ability or as a set of specific skills.

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