3.6 ELOQUENT SCIENCE: A COURSE TO IMPROVE SCIENTIFIC AND COMMUNICATION SKILLS

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1. ORIGINS OF THIS COURSE AND BOOK

One of the most common weaknesses of undergraduate and graduate science students is their skill at communicating. Yet, writing and speaking skills are in demand at many jobs for atmospheric science graduates, regardless of what career path students take after graduation.

For six years, I developed and taught a communication skills workshop at the National Science Foundation–funded Research Experiences for Undergraduates program in Norman, Oklahoma (Zaras 2005; Gonzales-Espada and LaDue 2006). In 2005, I attended an AMS-sponsored specialty conference, and I was disappointed at the low quality of presentations from prominent researchers—many well-respected ones with years of receiving federal research funding and publishing journal articles. Although I had been bored at conferences before, this time I snapped. The lessons I was teaching to undergraduates needed to be heard by others. *Eloquent Science* (Fig. 1) was born.

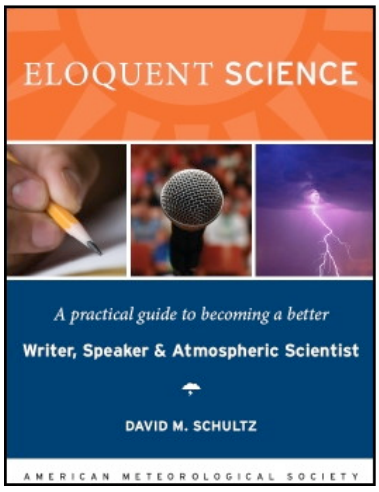

Figure 1. The course was designed around this book: *Eloquent Science,* published by the AMS in 2009.

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2. HOW TO DESIGN A UNIVERSITY COURSE IN COMMUNICATION SKILLS

Serious writing of the book began in November 2006. The first complete draft of the book was finished in late August 2008, and the final version was submitted in late March 2009. While the book was nearing completion, I adapted its lessons to a 14-week course "Communication Skills for Scientists" at the University of Helsinki during the winter of 2008–2009. This article summarizes how I converted the workshop and book into a course focused on scientific communication skills. Ideas on how specific aspects of this course could be adopted in regular science curricula courses are included at the end of this article and in the Resources section of eloquentscience.com.

Feedback from the students comes from two evaluations, one at week 5 and one at week 14, at the end of the course. Course evaluations were based on the standard university evaluation form, but I included additional questions to evaluate the success of specific assignments and lectures.

One outcome of the week-5 evaluations was that the students felt that the course was too demanding for a mere 3 op. credits (1 op. credit in the Finnish system is roughly equivalent to about 2.5 hours per week spent on the course inside and outside of class). Therefore, I increased the number of credits to 5 credits, satisfying nearly all the students on the week-14 evaluations.

The class met once a week for a 2.5-hour period from late October 2008 through the end of February 2009 (excluding holidays). Of the 38 students who signed up and attended one of the first two lectures, 29 students (76%) completed the course. Of those 29, 24 (83%) were atmospheric science students and 28 (97%) used English as a second language. Although the course was intended for undergraduates and graduates, all but 3 or 4 were working on a Ph.D. The rest were undergraduates and M.S. students.

The course was designed to improve the students' public speaking skills and to bring them closer to completing a submission-quality manuscript. As such, when I advertised the course, I encouraged potential students to be actively working on a journal article, conference extended abstract, or dissertation.

Most of the students indicated some desire to write a thesis or a specific research article, although some indicated no specific project. For those students, I recommended writing a review article on something of scientific interest to them. In the week-14 evaluations, some of these students would complain that doing the assignments in the course was difficult for them, a point I return to later in this article.

I wanted the course to meet once a week for several hours so that students had enough time to engage in planned group activities, activities that a regular 75-minute class period might limit. The only time available during the week for such a course was 2:15–4:45 p.m. on Monday afternoon. Even by breaking up the classroom period with a 10-minute break after 60 minutes every week and small-group exercises nearly every week, some students felt that this period was too long.

I recommended that the students buy two books: *The Elements of Style* (Strunk and White 2000) and *Presentation Zen* (Reynolds 2008). Having read more than 30 books on communication skills while researching the content for *Eloquent Science*, I felt these books were the two most essential purchases. The lectures would be supplemented with Gopen and Swan's (1990) "The Science of Scientific Writing" and excerpts from my forthcoming book, as well. The excerpts from *Eloquent Science* included chapters on paragraphs, sentences, and words (Chapters 8–10), a chapter for authors for whom English is not a native language (Chapter 16), an appendix on punctuation (Appendix A), and Pamela Heinselman's "How to Read and Critique a Scientific Paper" (pp. 232–233). The students said that all three sources were useful, although they found that the excerpts from *Eloquent Science* were the most useful, followed by *The Elements of Style* and *Presentation Zen* (Fig. 2), likely a result of my book being directed more towards their needs as early-career scientists.

The homework assignments were designed for about 5 hours a week of work outside of the class period. These assignments amounted to 50% of the course grade. The final class presentation and class participation amounted to 25% each of the course grade. There were no exams.

3. SURVEY ON SCIENTIFIC COMMUNICATION

On the first day of class, I gave the students a 30-question survey on scientific communication. This survey was previously given to participants at the 14th Cyclone Workshop in Quebec in late September 2008. Some of the results are presented below.

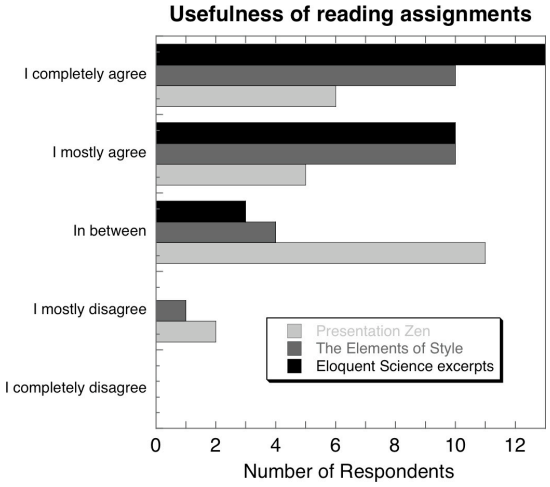

Figure 2. Number of respondents on the final course evaluation asking about the usefulness of the three major reading assignments: *The Elements of Style, Presentation Zen,* and excerpts from *Eloquent Science*.

- Forty-three percent had published at least one peer-reviewed scientific article.
- Seventy percent have considered or would consider publishing in an online-only journal.
- Forty-seven percent have posted or will post their published articles online.
- Nineteen percent started their writing projects with outlines less than half of the time, 35% used outlines most of the time, and 46% outlined 90% or more of the time.
- Fifty-eight percent would consider a title written as a question appropriate.
- Sixty-one percent of respondents felt that first-person pronouns are inappropriate in the body of a scientific paper.
- Twenty-six percent found it acceptable to republish the methods section verbatim in multiple papers to the same journal.
- Six percent knew the difference between an *en dash* and an *em dash* and how to use each one.
- Regarding multipart manuscripts (Part I, Part II, etc.), 25% thought that they were acceptable in most cases, 59% in some cases, and 16% rarely.
- Sixty-three percent believed that a publication written by a professor based on an M.S. thesis of a student who left the field of atmospheric science should have the author order "Student and Professor."
- Thirty-nine percent believed that submitting a conference abstract on research that has not been started yet is acceptable.

Other questions on the survey gauged students' opinions about the order they write and read the sections in journal articles, open access versus page charges for publishing, what they thought the mean

rejection rate is among 46 journals that publish atmospheric science (the correct answer is 37%, Schultz 2010), their biggest weaknesses in writing using the English language, their biggest challenges in writing a scientific manuscript, and what resources they use when needing help writing a scientific article. A future article will present more results from the survey and compare the results from the class to those from the respondents at the Cyclone Workshop.

4. COURSE CONTENT

In the first week, I introduced the students to four precepts.

1. *You can be taught to be a better writer.*
2. *Writing helps you think.*
3. *We write for our audience, not for ourselves.*
4. *There is no single way to write something. But, there may be better ways.*

These precepts pervade the content of the course and the book.

Although the course material is presented loosely in the order it appears in the book, I made some changes to get the students engaged in writing early in the course and to ensure that I covered the most important topics early in the course, in case I got behind my schedule and had to drop topics later. The content of the course appears in the following table. The chapter or chapters in *Eloquent Science* most closely related to the course material is listed in the third column.

Week	Content	Chapters
1	Introduction and overview of writing skills, how to provide constructive criticism and how to receive it, writing effective titles	3, 20, 21
2	Nonlinear reading, title writing	3, 4
3	How to publish a manuscript, writing effective abstracts, similarities and differences between conference and journal abstracts, parts of a scientific manuscript	1, 4, 6, 23
4	Combating writer's block, brainstorming and outlining. Writing effective paragraphs and sentences	5–8
5	Sentences and words	9–10
6	Effective figures	11
7	Citations, authorship, ethics	12, 14, 15
8	No class (professor at AMS Annual Meeting)	
9	Writing conference abstracts, delivering oral presentations, being asked questions and giving answers, challenges to giving effective presentations	23, 24, 26, 28
10	Constructing the slides	25–26
11	How to write and respond to reviews	19–21
12	Posters	27
13–14	Final class presentations	

5. HOMEWORK ASSIGNMENTS

Each week had a different homework assignment. This assignment may have involved a reading assignment, writing some of their project, preparing their final presentations, or one of the following exercises.

- The first homework assignment was to pick the titles from about 20 articles from a table of contents of a journal. Lipton (1998) defines the five characteristics of a desirable title as informative, accurate, clear, concise, and attention-commanding.

  Score each title on each of Lipton's five criteria (1=excellent, 2=adequate, 3=poor). For every article that has at least one score of 3, rewrite the title to improve it. (If attention-commanding=3, imagine you are writing the title of a conference presentation, where you have a bit more latitude in being provocative.)

  I felt this exercise was a good start to the class for several reasons. First, the assignment gave the students a concrete assignment with concrete criteria. Having concrete, goal-oriented tasks first builds the students' confidence and satisfies their needs as goal-seeking learners (Roebber 2005). Second, the assignment showed the students that the peer-reviewed literature was fallible. Specifically, given the importance of the title to attracting an audience to an article and how easy it is to improve most titles, the exercise showed how little thought some authors put into their titles. Third, the students could easily improve upon many of the titles, without having read much more than the abstract. Fourth, I thought the assignment would be fun for the students and provide the opportunity for some humor in seeing how bad some of the titles were. Finally, the exercise provided a natural opportunity to follow up during the next class period with an in-class exercise (section 6).

- *Read the assigned manuscript, then write a title and abstract for it.*

  The article was Weinstein and Sanders's (1989) "Wind increases in rapid marine cyclogenesis," which was a 2.5-page article with no abstract. I redacted all of the article's identifying information.

Most students (84%) found this to be a useful exercise.

- *Read a published article that you are critical of, shows results different from yours, or that shares a different opinion from you. Write a review of this article.*

  Most students (77%) found this exercise useful, although a few missed the point of choosing something they disagreed with or they didn't follow the proper format of a review.

One of the most interesting assignments I gave (and also one of the most polarizing among the students) was the brainstorming exercise. The assignment was motivated by the chapter on brainstorming in *Eloquent Science*. Although I felt obliged to say something about brainstorming in the book, I wondered whether any readers would find it useful. After all, how many of us follow the advice that we were taught in school to brainstorm before writing? I would think very few. Thus, I wanted to test if the students found a brainstorming session useful.

- *Consider the paper (or review article) that you want to write and spend a solid 90 minutes brainstorming. Afterward, revise your notes, looking for connections. Identify connections, and revise your notes to make a coherent outline of the paper.*

To ensure that they took the session seriously, I emphasized that a minimum of 90 minutes with no distractions was required. I figured that they would probably write down everything they could think of in 30–45 minutes, but they needed to push their mind beyond that, looking for other connections and ideas. How often do we take the time to sit undisturbed and think about our research?

Curious about their impressions of this exercise, I asked during the next class period. Some students felt that this was a waste of time, whereas others gained new insight into their research because they were forced to keep thinking beyond the point where the thinking came easy. On the evaluation form, I asked students whether they thought about their research topic in a new way during this exercise. Figure 3 shows one of the biggest spreads on any question from either evaluation. Despite this result, only two respondents (8%) disagreed with the statement that, "The brainstorming homework was a good use of time." My view is that this exercise was a worthy one, helping take half the class to places that they had not been before in thinking about their research problem.

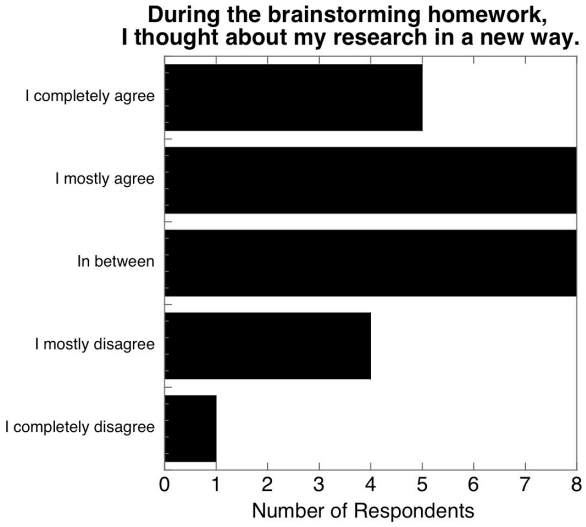

Figure 3. Number of respondents on the mid-course evaluation to the statement "During the brainstorming homework, I thought about my research in a new way."

6. IN-CLASS ASSIGNMENTS

The only sure way to become a better writer is to write more and write more often. Thus, I wanted to minimize the amount of lecturing I did in the course, even if it made more work for myself in planning exercises and then grading them. To reduce the dependency of the students upon lecture material, in-class assignments were common. Here is a selection of some of the in-class assignments.

- In the first homework assignment (section 5), each student rated the quality of 20 titles of published journal articles. During the next class period, I asked the students to bring their list to class, and, within a group of three students, select the absolute worst title among them all and propose a new title. The group was then responsible for presenting the results in front of the class, often to the snickers at the poorly written titles coming from the audience. This exercise was another illustration that the peer-reviewed literature is not necessarily well written and that the students can do better with just a little bit of effort.

- Peer-reviewing of other students' work was a common activity during the in-class assignments. The class was broken up into groups of three students rotating each others' writing samples amongst themselves, making comments directly on the paper and having open face-to-face discussions between authors and reviewers. For their homework, the students would revise their own writing based on the written feedback. Most students (81%) found this helpful to their learning.

- Précis (pronounced *pray-see*) is an exercise to condense text that retains much of the original author's words, unlike paraphrasing that condenses text using the words of the person doing the paraphrasing. I find that précis easily shows me the redundancies and superfluous words and phrases in blocks of text (whether my own or others'). For the in-class exercise, the students were to write a précis from the first paragraph of a *Science* article on sequencing woolly mammoth DNA (Poinar et al. 2006). Then, students read their précis to the rest of the class and discussed it. Many students found that they could condense the 244-word paragraph to between 30% and 60% of its original length. Just over half of the students (54%) found this exercise useful for learning how to make their writing more concise.

7. FINAL IN-CLASS PRESENTATION

The following assignment was the final in-class presentation.

You are seeking funding for your research project that you have been writing about. You have identified a private foundation, The Eloquent Science Foundation, which funds basic and applied science. Assume that you have already submitted a detailed written proposal with budget and this presentation is your final opportunity to convince them to fund your research. Give it your best shot!

Although the panel that will approve your proposal is scientifically literate (i.e., they have college degrees in science), they are not specialists in your field. You are to prepare an 8-minute presentation to this panel describing your proposed research and why it is important that it be funded. Your presentation to the panel will be different from a typical scientific presentation at a conference where you present results of your study. Although you may present some results in your presentation to illustrate that your proposed research yields feasible results, the focus of your presentation should be on persuading the panel to fund your research. You do not need to discuss your budget or resources with the panel. Focus on explaining the importance of the work to science and society. Place your work in the context of the rest of your discipline. Why is it important? What new advances may result from your work and its applications? Are opportunities available to patent your results or grow a business? How will your results benefit society?

After your presentation, there will be two minutes for the panel to ask questions. The panel turns out to be the rest of the class. Everyone in class will be providing comments, as well as numerical scores, on your presentation that will be added together to contribute to your grade for this project. The people with the best scores will win prizes. (Unfortunately, my resources are not sufficient to fully fund your proposed research!)

You will be graded on your presentation skills, how well you use the English language, the quality of your slides, and how convincing your argument is. Your grade will be a combination of my scores and those of the panel (the rest of the class).

To the panel: Your written evaluations on each presentation will be graded for the quality of your comments and the insight you have into the others' presentations. I will remove the panelists' names from the evaluations and give them to the speakers at the end. So, your comments will help your classmates improve in the future. Do not hold back on your constructive criticisms.

The final projects were held over two days. Although the students presenting during the first week were at a disadvantage, the quality of the presentations was not significantly different from one week to the next. Despite the explicit instructions to make their presentation accessible to nonspecialists, 6 of the 29 presentations (21%) were not what I would consider appropriate for the panel, indicating the difficulty that students (if not scientists, in general) have presenting their research to nonspecialists. A positive outcome was that 13 (45%) of the presentations fought the urge to prepare a wordy scientific presentation and used aspects of the *Presentation Zen* minimalist approach to presentations (almost the same number that found the book useful; Fig. 2). A few students even had fun with their presentations, envisioning a field program (complete with scientific-sounding acronym) or field research instrumentation. In the week-14 evaluations, 77% of the respondents found these presentations worthwhile.

8. OTHER RESULTS FROM THE CLASS EVALUATIONS

Because the majority of the class time was focused on writing and there was just one opportunity for delivering an oral presentation, it is not surprising that most students felt that their writing improved more than their oral presentation skills (Fig. 4). Several commented that some of the best things about the course were that the writing assignments were "demanding," "made me think," and "made me think about writing and how to improve."

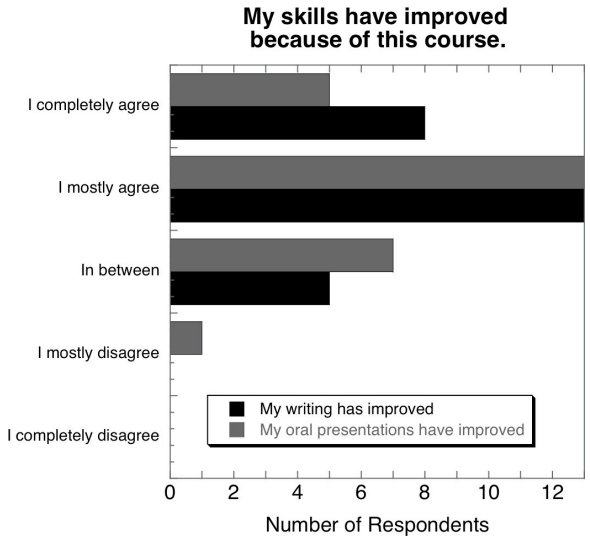

Figure 4. Number of respondents on the final course evaluation to the statements "My writing has improved because of this course," and "My skills at preparing and giving oral presentations have improved because of this course."

Despite this emphasis on writing, students wanted *even more time* spent on writing: how to write introductions, conclusions, and the other sections of the manuscript, and more on the structure of manuscripts. They also wanted more time spent on writing paragraphs and sentences and more time spent revising their own writing during the in-class peer reviewing.

The most serious weaknesses of the course were that the pace was a bit too slow for some people (although 78% thought that the pace was OK), it was difficult for undergrads who didn't have a writing assignment (despite the recommendation that having one would make the class easier), and it needed a tutorial section for one-on-one interaction (few students however, ever took advantage of my open-office policy to stop by and talk about their writing). Because most of the class (as well as the professor) were atmospheric scientists and my examples drew heavily from atmospheric science, 22% of the respondents wanted more examples from outside atmospheric science. Indeed, these others came from electronics, geophysics, geodesy, physics, and economics.

At the end of the course, 92% of respondents were satisfied with the course, and 89% said that they would recommend it to other students. Even the subjective grading was not a problem with most students (76%) finding the grades fair.

9. CHALLENGES

Despite having written a book on communication, I found it difficult to get the students to open up and discuss in the classroom setting. Finnish students in particular are quite independent and introspective, shying away from offering their opinions and even answering factual questions in class. According to some sage advice I received from a Finnish colleague after the frustration of teaching my first course in Helsinki in 2007 (http://daveinsuomi.blogspot.com/2007/02/mesoscale-observing-network-class.html), one key to opening up the discussion is to start within the small groups. In selecting the three-member groups, another colleague told me to avoid creating a three-member group with one woman, who would usually be reluctant to speak up in the presence of two usually less-inhibited males. Because of the small size of the classroom relative to the large number of students, mixing up the groups beyond the nearest-neighbor approach was usually difficult, but I did think that the small-group discussions, followed by the whole-class discussions, was a successful approach, in general.

This type of course demanded lots of grading, which was difficult to find the time to do thoroughly, especially for assignments written by nonnative English speakers. A native English-speaking teaching assistant (rare in Finland) would have helped ease this burden. Consequently, peer review was a necessary part of the course to help provide more thoroughness than I alone could have provided.

But, peer review has the added benefits to the students of receiving feedback from their peers rather than an authority figure (the professor). Also, students tend to focus on the small-scale issues because writing (or editing) for novices (scientific and English-language) is relatively new, so they focus on the mechanics. With more experience, writing becomes a reflective process (e.g., Scardamalia et al. 1984). Thus, when I graded the students' writing assignments, I usually stuck to the larger-scale issues with the writing (organization, coherence, precision), leaving language and grammar errors alone.

The complaints by the students without preplanned writing projects could have been resolved by offering two versions of the course: one tied to those writing a paper, and another tied to those not writing their own paper. That said, I have a hard time imagining a writing course absent a writing assignment tailored to the individual students' needs. If this course were to be taught to students lacking their own writing assignment, it would be preferable to assign a topic for them to work on (e.g., a literature review, position paper, research proposal, graduate school application

essay). Thus, I probably needed to exert more control over their writing assignments early in the class.

10. WHERE WE'VE BEEN, WHERE WE'RE GOING

The origin of this course was a communications workshop for undergraduate students that I started teaching in 2000. By 2005, the last time I taught it, the workshop consisted of two four-hour periods, with the first four hours being nearly all lecture material and the second four hours being peer-review evaluation of writing samples written by the students.

Over the years, the course has been reorganized, distilled, and presented in different contexts (e.g., invited talks to university students, lectures at the AMS Student Conference since 2008). This last academic year at the University of Helsinki was the first time that the course content was expanded to a 14-week university course.

I have also considered an intermediate-length course one week long of intensive lectures and in-class exercises in the morning and individual time for writing or presentation preparation in the afternoon. Such a course might be given in a summer-school or retreat setting, like some singer–songwriter retreats. [For examples, see http://www.inspiresong.com/, http://www.reorafting.com/site/retreats/songwriter_retreat.html, and http://www.heatherfrahn.com/news.htm#retreat.] Such seclusion from the daily grind has obvious benefits to keeping the students focused on writing, as this lack of focus is one of the common excuses for not starting or completing writing assignments.

Although the book was developed from a workshop for undergraduates, it was designed for all levels of students, as well as practicing scientists. Thus, aspects of this course could be incorporated into existing curricula at colleges and universities. More writing, more speaking opportunities, and more opportunities for peer review within existing classes will help contribute to a greater emphasis on communication skills for students without compromising the traditional lecture-based material in courses. In fact, evidence suggests that the more opportunities for students to express themselves in situations that mimic the real world, the better the learning experience.

To help give some guidance to instructors wanting to incorporate more writing and speaking exercises in their classroom, I recommend Gross Davis (1993). Also, a complete chapter "Incorporating Communication Skills into Teaching" can be found on the Resources section of the eloquentscience.com Web site. The chapter is an outtake from the book and is now made freely available to all instructors.

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