

A UNIVERSITY LABORATORY COURSE TO IMPROVE SCIENTIFIC COMMUNICATION SKILLS

BY DAVID M. SCHULTZ

A course emphasizing student participation over lectures shows how scientific communication skills can be taught within the regular science curriculum.

I had been bored at conferences before, but never this badly. I was attending an American Meteorological Society (AMS) specialty conference, and I was unimpressed by the presentations from prominent researchers—many of whom were well respected with years of receiving federal research funding and publishing journal articles. For the previous six years, I had been teaching undergraduates how to give better presentations at the National Science Foundation–funded Research Experiences for Undergraduates program in

Norman, Oklahoma (Zaras 2005; Gonzales-Espada and LaDue 2006). These lessons needed to be heard by these speakers. The idea for the book *Eloquent Science: A Practical Guide to Becoming a Better Writer, Speaker, and Atmospheric Scientist* (Schultz 2009) was born.

Several years later when the book was nearing completion, I adapted its lessons to a laboratory course “Communication Skills for Scientists” at the University of Helsinki during the winter of 2008/09. This article summarizes how I converted the workshop and book into a 14-week laboratory course focused on scientific communication skills and what I learned while teaching this material.

DESIGN OF THE LABORATORY COURSE.

I had heard the complaints from my colleagues that undergraduate and graduate students do not know how to write or speak. Often, the weaknesses of the students would be revealed during the writing and defense of their theses, and these skills would be needed if the students pursued a future research career. Even students who write well often require education in how to write a scientific document, which is where a strong advisor can make a positive difference. Often, advisors either do not have the commitment or the skills (or both) to work with students to improve their communication skills. Accordingly, the weaknesses of the advisors are passed down to the students.

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The abstract for this article can be found in this issue, following the table of contents.

DOI:10.1175/2010BAMS3037.1

A supplement to this article is available online (10.1175/2010BAMS3037.2)

In final form 20 March 2010
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Regardless of what career path students take after graduation, writing and speaking skills are in demand at many jobs. The College Board's National Commission on Writing found that two-thirds of salaried employees in large U.S. companies required writing as part of the job, and writing ability is considered during hiring and promotions at half of those companies ("Writing: A Ticket to Work . . . Or a Ticket Out: A Survey of Business Leaders," available online at www.collegeboard.org/prod_downloads/writingcom/writing-ticket-to-work.pdf).

Also, a survey of private sector companies conducted by the American Meteorological Society in 1995 indicated that colleges and universities could be better preparing individuals for employment in the private sector by "stressing communication skills" (Houghton et al. 1996). Communication skills was also the second-most listed course that should be taught in meteorology programs to prepare students for private sector jobs, beating synoptics, dynamics, and computer skills. As a result of this kind of demand, many college and university science programs are requiring more writing in many of their core curriculum classes. The course at the University of Helsinki was an opportunity not only to teach these skills to students but also to test some of the concepts in *Eloquent Science*.

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 in order to give the students a writing project to be working on during the course and to invest the students in the success of the course. For students without a project, I recommended writing a review article on something of scientific interest to them.

The class met once a week for a 2.5-h period from late October 2008 through February 2009 (excluding holidays)—my request so that students had enough

time to engage in planned group activities, activities that a regular 75-minute class period might limit. Even by breaking up the classroom period with a 10-minute break after 60 minutes and small-group exercises, some students felt that this period was too long, especially because the class was late on Monday afternoon.

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 draft excerpts from *Eloquent Science*. Although the course material was presented loosely in the order it appears in *Eloquent Science* (Table 1), 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 schedule and had to drop topics.

Because of the emphasis on group activities, I did not allow students to audit the laboratory course. 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. Of the 28 students, 24 (86%) were Finnish. All but three or four were working on a Ph.D.; the rest were undergraduates and M.S. students. Forty-three percent of the class had published at least one peer-reviewed scientific article.

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 three 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 five, satisfying nearly all the students on the week-14 evaluations.

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 (subjectively determined by me) amounted to 25% each of the course grade. There were no exams.

PRECEPTS OF THE COURSE

These four precepts laid the foundation for the course.

- 1) You can be taught to be a better communicator.
- 2) Writing and speaking improves your thinking on your topic.
- 3) We communicate for our audience, not for ourselves.
- 4) There is no single way to write or say something.
But, there may be better ways.

Each week had a different homework assignment. This assignment may have involved reading, writing some of their project, or preparing their final presentations. Two other examples included the following assignments.

HOMEWORK ASSIGNMENT: TITLE WRITING. Lipton (1998) defines the five characteristics of a desirable title as informative, accurate, clear, concise, and attention commanding. The first homework assignment was to pick the titles from about 20 articles from a table of contents of a journal and rate them according to Lipton's five characteristics.

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.)

TABLE 1. Course content.		
Week	Content	Chapters of <i>Eloquent Science</i>
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	

STUDENT PERCEPTIONS ON SCIENTIFIC COMMUNICATION

On the first day of class, I gave the students a 30-question survey on scientific communication. This survey was slightly modified from one previously given to participants at the 14th Cyclone Workshop in Quebec, Quebec, Canada, in late September 2008. The questions arose during the writing of *Eloquent Science*, when I wondered what other authors and students felt about certain issues. The results of the survey were discussed in class during the second class period. Some of the results are presented below.

- 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.
- Fifty-eight percent of respondents felt that first-person pronouns are inappropriate in the body of a scientific paper.
- Twenty-seven 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.; Schultz 2010b), 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 journals that publish atmospheric science (the correct answer is 37%; Schultz 2010a), 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. More results from the survey and a comparison to survey results from respondents at the 14th Cyclone Workshop are discussed in the electronic supplement to this article (<http://dx.doi.org/10.1175/2010BAMS3037.2>).

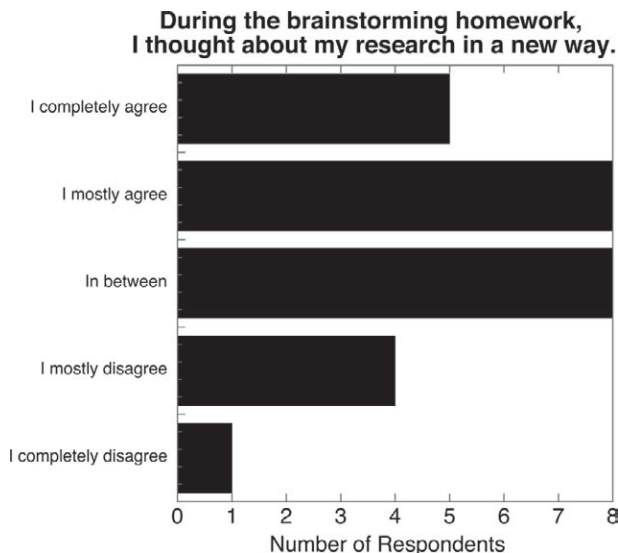


FIG. 1. Number of respondents on the week-5 evaluation to the statement “During the brainstorming homework, I thought about my research in a new way.”

This exercise was a good start to the class for several reasons. First, the assignment gave the students an 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 the first in-class exercise (described later in this article).

HOMEWORK ASSIGNMENT: BRAINSTORMING. One of the most interesting assignments I gave (and also the most polarizing) 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? How often do we take

the time to sit undisturbed and think about our research? 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.

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 1 shows one of the biggest spreads on any question from either evaluation, with 13 respondents who agreed, 5 who disagreed, and 8 who were neutral. Despite this result, only two respondents (8%) to a different question 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.

IN-CLASS ASSIGNMENTS. Nobel Prize-winning author Doris Lessing said, “You only learn to be a better writer by actually writing.” Thus, I wanted to minimize the amount of lecturing I did in the laboratory course, even if it made more work for myself in planning exercises and then grading them. Here is a selection of some of the in-class assignments.

In the first homework assignment (described earlier), each student rated the quality of 20 titles of published journal articles. During the next class period, I asked the students to bring their lists 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 further demonstrated to the students 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 among 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 an 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, suggesting that I might

have spent more time working with the students on applying précis to their own writing.

FINAL IN-CLASS PRESENTATION. The sidebar "Final class presentation assignment" lists the assignment for the final presentation. The final projects were held over two days. 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 in presenting the value of 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* (Reynolds 2008) minimalist approach to presentations (almost the same number that found the book useful from the week-14 evaluations). A few students even had fun with their presentations, envisioning a field program (complete with scientific-sounding acronym) or mobile field research instrumentation. In the week-14 evaluations, 77% of the respondents found these presentations worthwhile.

OTHER RESULTS FROM THE CLASS EVALUATIONS. Because the majority of the laboratory was focused on writing and there was just

FINAL CLASS PRESENTATION ASSIGNMENT

You are seeking funding for your research project about which you have been writing. You have identified a private foundation, The Eloquent Science Foundation, that 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 contrib-

ute 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. Your comments will help your classmates improve in the future. Do not hold back on your constructive criticism.

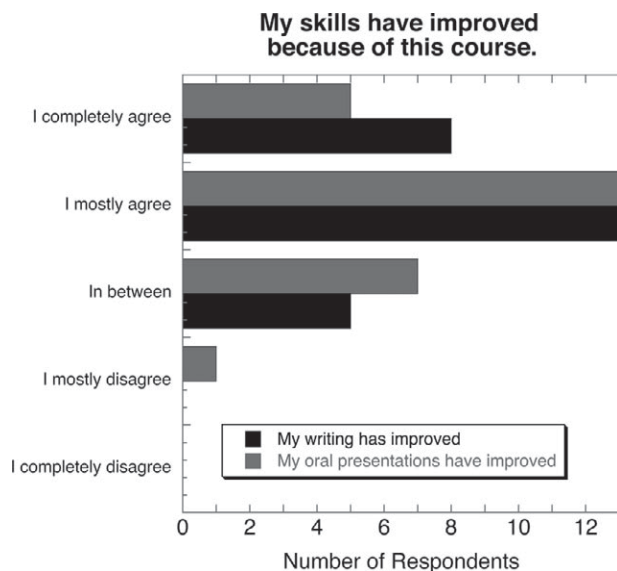


FIG. 2. Number of respondents on the week-14 evaluation to the statements “My writing has improved because of this course” and “My skills at preparing and giving oral presentations have improved because of this course.”

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. 2). 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.”

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 reviews.

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), that it was difficult for undergrads who did not have a writing assignment (despite my recommendation that having one would make the class easier), and that the course 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 the course). Because most students (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.

CHALLENGES. Despite having written a book on communication, I found it difficult to get the students to open up and discuss during the laboratory setting. Finnish students in particular are quite independent and introspective, shying away from offering their opinions and even answering factual questions in class. [Ventola (1992) provides a frank perspective on the challenges that Finns face communicating using scientific English.] According to some sage advice I received from a Finnish colleague after the frustration of teaching my first course in Helsinki in 2007, one key to opening up the discussion is to start within 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. [After the class was over, I discovered holistic grading (Dyrud 1994), where the students are given a grade of *excellent*, *acceptable*, or *unacceptable* and are given a chance to make revisions. Holistic grading is a process that is more similar to the real world, reduces the subjectivity of grading, allows for students to revise their work, and can save the instructor an incredible amount of time from making numerous minor comments. Next time I teach, I will incorporate this technique.]

However, peer review has the added benefit 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 laboratory absent a writing assignment tailored to the individual student's needs. If this laboratory 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.

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

The origin of this laboratory course was a communications workshop for undergraduate students that I started teaching in 2000. By 2005, the workshop consisted of two 4-h 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 laboratory course at the University of Helsinki was the first time that the content was expanded to 14 weeks.

I have also considered an intermediate-length laboratory 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 during a summer school or 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, exercises and other aspects from this course could be incorporated into existing curricula at colleges and universities (see sidebar on "Incorporating writing and speaking into a core curriculum course"). 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 fact, evidence suggests that the more opportunities for students to express themselves in situations that mimic the real world, the better the learning experience.

ACKNOWLEDGMENTS. I thank all the students over the years that attended and provided comments to improve

INCORPORATING WRITING AND SPEAKING INTO A CORE CURRICULUM COURSE

Many of the exercises from this course on communication skills can be employed outside of this course. For example, even core curriculum courses can include writing assignments and lessons to help improve student writing incrementally. For example, remove the abstract from an article and have the students write a new abstract. In the University of Helsinki course, I used Weinstein and Sanders's (1989) "Wind increases in rapid marine cyclogenesis," a 2.5-page article with no abstract. Most students (84%) found this to be a useful exercise. Another exercise is to give them a paper (perhaps already published), an article where the research approach can be questioned, or an article that has an unexpected result, and ask the students to write a review. Most students (77%) found this exercise useful, although a few missed the point of choosing something they disagreed with or they did not follow the proper format of a review, despite having had a lecture on the structure of a review. Other resources to give instructors ideas about how to include writing and speaking exercises in the classroom include the following:

- Gross Davis (1993) provides some guidance to instructors wanting to incorporate more writing and speaking exercises in their classroom.
- Market (2006) found that students are more likely to make better forecasts on days with precipitation if they write an area forecast discussion.
- "Incorporating writing skills in a measurements laboratory" by Professor Petra Klein of the University of Oklahoma appears in Schultz (2009, p. 338).

An outtake chapter from *Eloquent Science*, "Incorporating Communication Skills into Teaching" can be found on the Resources section of eloquentscience.com.

the workshops and courses I taught. I also thank John Knox, Daphne LaDue, Paul Croft, and two anonymous reviewers for their comments on earlier versions of this article. Partial funding for Schultz comes from Vaisala Oyj.

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A UNIVERSITY LABORATORY COURSE TO IMPROVE SCIENTIFIC COMMUNICATION SKILLS

Perspectives on Scientific Writing from Students and Faculty

BY DAVID M. SCHULTZ

This document is a supplement to “A University Laboratory Course to Improve Scientific Communication Skills,” by David M. Schultz (*Bull. Amer. Meteor. Soc.*, **91**, 1259–1266) • ©2010 American Meteorological Society • Corresponding author: Dr. David M. Schultz, Finnish Meteorological Institute, P.O. Box 503, Erik Palménin Aukio 1, FI-00101, Helsinki, Finland • E-mail: david.schultz@fmi.fi • DOI:10.1175/2010BAMS3037.2

SUMMARY. A written survey was conducted to ascertain the respondents’ attitudes and approaches toward scientific writing. The survey was administered to two groups: 32 students of the class “Communication Skills for Scientists” at the University of Helsinki during week 1 in October 2008 (UH) and 44 of the roughly 90 attendees of the 14th Cyclone Workshop in Quebec, Quebec, Canada, in September 2008 (CW). Although nearly all the members of the UH group were early in their careers, the CW group was separated into two groups: an early-career group composed of 17 students and postdoctoral fellows (CW-EC) and 26 professors, scientists, and forecasters (CW-Rest). Their responses showed that more-experienced authors generally support multipart manuscripts and the use of first-person pronouns in the body of a scientific paper, whereas the early-career groups were more evenly split. In contrast, early-career authors were more amenable to open-access journals. Respondents typically read the parts of a manuscript out of order, starting with the title and abstract, then proceeding to the introduction or conclusions and figures next, leaving the discussion, tables, and data/methods to the end. Respondents usually write their manuscripts out of order, as well. Most create the figures first, then write the data/methods and introduction next, ending with the conclusions, title, and abstract, although a few authors write the title first. Responses to the rest of the 30 questions in the survey are discussed in this supplement.

A written survey was answered by 32 students in week 1 of the class “Communication Skills for Scientists” at the University of Helsinki in October 2008 (responses denoted by UH), discussed by Schultz (2010c). Their responses are compared to those from 44 of the roughly 90 attendees of the 14th Cyclone Workshop in Quebec, Quebec, Canada, [in September 2008 (Quebec, Canada, responses denoted by CW; information about previous Cyclone Workshops can be found in Bleck et al. (1993) and Gyakum et al. (1999)]. The questions arose during the writing of *Eloquent Science* (Schultz 2009), as I wondered what students and other scientists in the atmospheric sciences felt about these issues.

DEMOGRAPHICS. A large difference existed between the UH and CW groups. Of the UH group, all but one (3%) was not a native English speaker, whereas all but 3 (7%) of the CW group were native English speakers.

Whereas the UH group was composed of 24 (86%) students, 2 (7%) junior scientists, 1 (4%) forecaster, and 1 (4%) other, the CW group was composed of 15 (35%) professors, 14 (33%) students, 10 (23%) researchers and scientists, 3 (7%) postdoctoral students, and 1 (2%) scientist/forecaster. Thus, the CW group was split into an early-career CW group (17 students and postdoctoral students, designated CW-EC) and the other 26 respondents (CW-Rest). (One respondent did not answer the question about their professional status.) This partition allowed a comparison

between two early-career groups: one primarily of native English speakers from North America and one primarily of nonnative English speakers from Finland. This partition also allowed comparison within the CW group between those early in their career and professors and research scientists.

Whereas 41% of the UH group had published a peer-reviewed scientific article, 82% of the CW-EC group had. There was an almost complete separation between the two CW groups by the number of peer-reviewed publications. Most respondents in the CW-EC group had 0, 1, or 2 publications, with four respondents having 4, 5, 6, and 7 publications. In contrast, most of the CW-Rest group had 10 or more publications, except for five respondents who had 2, 3, 5, 7, and 7 publications.

Percentages below are based on the total number of respondents to each question. Totals may not add up to 100% due to roundoff.

WRITING SCIENTIFIC ARTICLES.

- 1) *I consider the use of a question appropriate in the following title of a scientific journal article: “Are more observations necessarily required for improved forecasts?”*

UH:	TRUE 58%	FALSE 42%
CW-EC:	TRUE 76%	FALSE 24%
CW-Rest:	TRUE 77%	FALSE 23%

I asked this question to gauge how respondents felt about provocative titles for articles. The UH group was more conservative than the CW group.

- 2) *I believe it is appropriate for a first-person pronoun (“I” or “we”) to appear in the body of a scientific paper. (For example, “we selected the top 20 cases for inclusion in the climatology.”)*

UH:	TRUE 58%	FALSE 42%
CW-EC:	TRUE 47%	FALSE 53%
CW-Rest:	TRUE 73%	FALSE 27%

- 3) *I believe it is appropriate for a single author to use “we” in the body of a scientific paper.*

UH:	TRUE 36%	FALSE 64%
CW-EC:	TRUE 18%	FALSE 82%
CW-Rest:	TRUE 44%	FALSE 54%

I asked these two questions because most modern books and articles have suggested that limited use of the first person is acceptable (and even encouraged) in scientific manuscripts to make the writing more accessible. I agree that limited use of the first person is acceptable (Schultz 2009, 76–77). [Whitburn (1976) provides an impassioned plea arguing for more personality in scientific writing.] I wanted to see what people’s perceptions were about this topic. Although the UH and CW-EC groups were evenly split, the more-experienced CW-Rest group generally supports the use of first-person pronouns.

Personally, I recognize that “we” when meaning “you the reader and I the author” should be acceptable, although I would avoid “we” in a solo-authored paper of my own. Most respondents in all groups seem to agree.

- 4) *A conclusion section should not contain any information that was not already presented in the text.*

UH:	TRUE 82%	FALSE 18%
CW-EC:	TRUE 81%	FALSE 19%
CW-Rest:	TRUE 24%	FALSE 76%

Geerts (1999) argued that the readability of journal articles has decreased, in part because the authors have not written clear conclusion sections. He advocates not putting any new information in the conclusion

section that was not already presented in the text. Although the UH and CW-EC groups felt pretty strongly that conclusions should not contain any new information, the more-experienced authors in the CW-Rest group felt differently. (Some of the CW-Rest respondents noted the double negative in the question. Tough crowd.)

5) *I know the difference between an en dash and an em dash and how to use each one.*

UH:	TRUE 6%	FALSE 94%	
CW-EC:	TRUE 31%	FALSE 69%	
CW-Rest:	TRUE 35%	FALSE 62%	Maybe 4%

Hyphens (-), en dashes (–), and em dashes (—) are the least correctly used punctuation marks in scientific manuscripts. I wanted to see how many respondents were aware of the difference and how to apply each one. Most respondents, however, did not know.

6) *I believe multipart manuscripts (Part I, Part II, etc.) are acceptable.*

	1=IN ALL CASES	2=IN MOST CASES	3=IN SOME CASES	4=RARELY	5=NEVER
UH:	0%	25%	59%	16%	0%
CW-EC:	0%	41%	53%	6%	0%
CW-Rest:	0%	54%	46%	0%	0%

Multipart papers generally cause trouble for editors. Because they are two manuscripts linked, potential reviewers are reluctant to take them on, reviewers want more time to review two manuscripts, and reviewers are often more critical, all leading to longer times to publication, if not rejection (Schultz 2009, section 3.3; Schultz 2010b). I would advocate to any authors considering multipart papers to write them as independently as possible and submit them as separate manuscripts. Although the two early-career groups were lukewarm to multipart papers, more experienced authors in the CW-Rest group tended to favor multipart papers in most cases.

PUBLISHING. After implementing the first survey to the CW group, but before giving it to the UH group, I changed the wording on these next two questions so that they read more clearly.

UH: 7) *In deciding on a journal to publish my research, the cost of page charges (if any) is an important factor for me to consider.*

1=STRONGLY AGREE	2=AGREE	3=NEUTRAL	4=DISAGREE	5=STRONGLY DISAGREE
3%	36%	42%	18%	0%

CW: 7) *In deciding on a journal to publish your research, how important are page charges to you?*

	1=VERY MUCH	2=A LITTLE	3=SOMEWHAT	4=NOT MUCH	5=NOT AT ALL
CW-EC:	20%	33%	27%	20%	0%
CW-Rest:	19%	27%	50%	0%	4%

The cost to publish a manuscript can be free for some journals to several thousand dollars in other journals (particularly AMS journals). I wanted to get a sense of what the respondents thought about page charges. The early-career groups tended to worry less about page charges, but the CW groups exhibited slightly more concern about page charges.

UH: 8) *In deciding on a journal to publish my research, an open-access journal is an important factor for me to consider (i.e., immediate and free access of your published article online to everyone).*

1=STRONGLY AGREE 2=AGREE 3=NEUTRAL 4=DISAGREE 5=STRONGLY DISAGREE

23% 55% 23% 0% 0%

CW: 8) *In deciding on a journal to publish your research, how important is open access to you (i.e., immediate and free access of your published article online to everyone)?*

1=VERY MUCH 2=A LITTLE 3=SOMEWHAT 4=NOT MUCH 5=NOT AT ALL

CW-EC: 13% 38% 38% 6% 6%

CW-Rest: 16% 36% 24% 16% 8%

9) *I have considered or would consider publishing in an online journal only (no print copy).*

UH: TRUE 70% FALSE 30%

CW-EC: TRUE 88% FALSE 12%

CW-Rest: TRUE 72% FALSE 28%

10) *I post (or will post) my articles online (on your web page or on an internet archive) after they are published.*

UH: TRUE 47% FALSE 53%

CW-EC: TRUE 67% FALSE 33%

CW-Rest: TRUE 52% FALSE 48%

These last three questions were aimed at exploring the attitudes of respondents to open access. Articles published in open-access journals are considered to be more downloaded, to be more highly read, and to produce more citations (e.g., Lawrence 2001; Antelman 2004; Hajjem et al. 2005; Eysenbach 2006), although not all studies reach that conclusion (Craig et al. 2007). Even articles that are self-archived online get more citations (e.g., Lawrence 2001; Henneken et al. 2006). My experience is that Europeans are more likely to embrace open access, although North American early-career scientists are more likely to embrace detailed personal Web pages. The results of questions 8 and 10 support my experience, although the results to question 9 do not.

ETHICS.

11) *If I publish a graphic created from a dynamic Web page application (e.g., CDC Reanalysis page, Wyoming soundings, Plymouth State surface maps), I should cite the source in my manuscript.*

UH: TRUE 97% FALSE 3%

CW: TRUE 100% FALSE 0%

I am very happy to see that nearly everyone would give the source credit. Not every author does. In fact, some authors try to hide any indication of the source. That is unethical.

12) *An M.S. student graduates and leaves the field of atmospheric science. The supervising professor writes up the manuscript and submits it for publication. I believe the author order should be Student and Professor, not Professor and Student.*

UH: TRUE 63% FALSE 37%

CW-EC: TRUE 44% FALSE 56%

CW-Rest: TRUE 36% FALSE 44% Depends 20%

I designed this question to be somewhat vague. Arguably, this question did not provide complete information about the situation, as the experienced authors of the CW-Rest recognized. Was the original idea for the research project the professor's or the student's? That might make a difference how respondents answered this question. Not surprisingly, students, especially the UH group, would want the student's name first.

13) *I find it acceptable to republish the methods section (e.g., description of a mesoscale model) verbatim in multiple papers to the same journal.*

UH:	TRUE 27%	FALSE 73%
CW-EC:	TRUE 24%	FALSE 76%
CW-Rest:	TRUE 31%	FALSE 69%

Responses to this question were relatively consistent among all three groups. There are several ways to plagiarize your own writing, this question presenting one. Likely, you do not own your own writing once it is published if you signed a copyright agreement with the publisher. There is an excellent Web page on plagiarism and self-plagiarism at <http://facpub.stjohns.edu/~roigm/plagiarism>.

14) *Submitting a conference abstract on research that has not been started yet is acceptable.*

UH:	TRUE 39%	FALSE 61%	
CW-EC:	TRUE 76%	FALSE 24%	
CW-Rest:	TRUE 58%	FALSE 38%	Depends 4%

Known as fabstracts, Fairbairn and Fairbairn (2005, 4–5) said that submitting such conference abstracts was unethical. I wanted to see what the respondents felt about this. The UH group was least tolerant of fabstracts, followed by a more evenly split CW-Rest group, whereas the CW-EC group heavily favored fabstracts.

PEER REVIEW.

15) *As a reviewer, I should perform all derivations in the manuscript myself to ensure their accuracy.*

UH:	TRUE 55%	FALSE 45%
CW-EC:	TRUE 75%	FALSE 25%
CW-Rest:	TRUE 63%	FALSE 37%

Opinions vary about how much effort reviewers should put into verifying details of the manuscripts, with roughly half of the UH group believing in performing the derivations to three-quarters of the CW-EC group believing in performing the derivations.

UH: 16) *I think the editor should rely on the reviewer comments in deciding whether to publish a manuscript.*

1=STRONGLY AGREE	2=AGREE	3=NEUTRAL	4=DISAGREE	5=STRONGLY DISAGREE
10%	72%	10%	10%	0%

CW: 17) *How much should the editor rely on the reviewer comments in deciding whether to publish a manuscript?*

	1=VERY MUCH	2=A LITTLE	3=SOMEWHAT	4=NOT MUCH	5=NOT AT ALL
CW-EC:	47%	18%	35%	0%	0%
CW-Rest:	84%	12%	4%	0%	0%

Editors are entrusted with making the decision about publishing manuscripts. Reviewers provide guidance to that decision. Presumably, if the editor has chosen good reviewers and the reviewers provide good reviews, then the editor should rely heavily on the reviews. But, situations may arise where the editor needs to depart from the reviews. Interestingly, the more experienced CW-Rest group wanted editors to follow reviewers recommendations very closely. Remember that the next time you hear an author complain about the reviewers' comments.

17) *What do you think the average (mean) rejection rate is among 42 leading atmospheric science journals?*

Individual journals published by the AMS reject 19–39% of manuscripts. For 46 journals that publish in the atmospheric sciences, the mean rejection rate is 37% (Schultz 2010a). (The 46 journals are more than the 42 that I had data for at the time the surveys were administered.)

Figure 1 shows the results of this question. The UH and CW-EC responses exhibited similar distributions (although the CW-EC group had no values more than 70%), and the most prolific publishers (CW-Rest) were tightly packed around the average value.

18) *A manuscript describing a case study of explosive cyclogenesis in the eastern United States is submitted to Monthly Weather Review. Although this case has not been described in the literature, no new scientific results are presented in the manuscript. Should the journal reject this manuscript?*

UH:	YES 43%	NO 40%	Maybe 7%	Other 10%
CW-EC:	YES 44%	NO 56%		
CW-Rest:	YES 27%	NO 55%	Depends 18%	

19) *A manuscript describes the improvement in the numerical forecasts of a tropical cyclone by assimilating satellite data using existing techniques. No new scientific results are presented in the manuscript. Should the journal reject this manuscript?*

UH:	YES 23%	NO 70%	Other 7%
CW-EC:	YES 44%	NO 56%	
CW-Rest:	YES 41%	NO 41%	Depends 18%

These questions were asked because *Monthly Weather Review* (the journal I serve as chief editor for) receives a number of papers that are simply synoptic case studies, numerical model simulations, or data assimilation case studies that lack new scientific results. Discussion among the editors about what to do with these manuscripts is ongoing. It would seem that respondents are generally split about what to do.

WRITING AND SPEAKING PREPARATION.

20) *What percent of your writing projects are started with an outline?*

Figure 2 shows the responses to this question. The majority of the respondents (59%) said that they started an outline 100% of the time. More experienced authors in the CW-Rest group were bimodal, with most either writing an outline or not writing an outline. Early-career groups (CW-EC and UH) had modes at 100% but were widely spread over most of the range.

UH: 21) *How many times do you typically rehearse a 10–15-minute conference talk out loud before presenting it?*

CW: 21) *How many times did you rehearse your talk out loud before this week's presentation?*

Figure 3 shows the responses to this question. The majority of the respondents (75%) rehearse their talk three times or fewer. The mode of the experienced group (CW-Rest) is zero with 42% of respondents, whereas all of the CW-EC group members practiced their talk at least once.

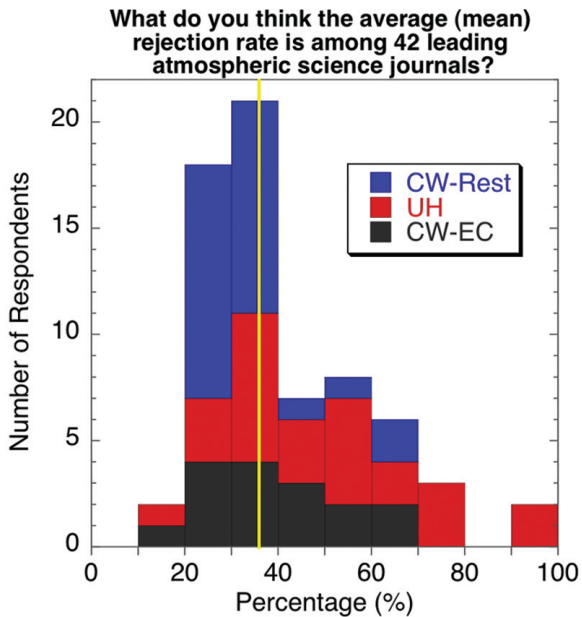


FIG 1. Number of respondents to the question “What do you think the average (mean) rejection rate is among 42 leading atmospheric science journals?” The yellow line represents the mean rate of 37% (Schultz 2010a).

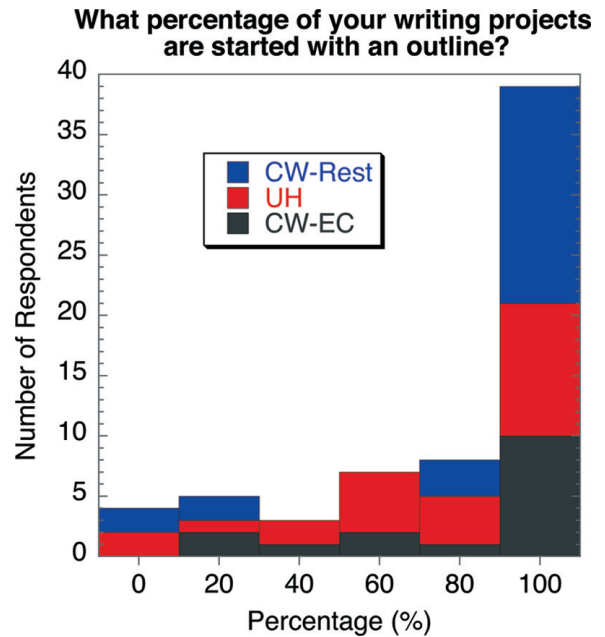


FIG 2. Number of respondents to the question “What percentage of your writing projects are started with an outline?”

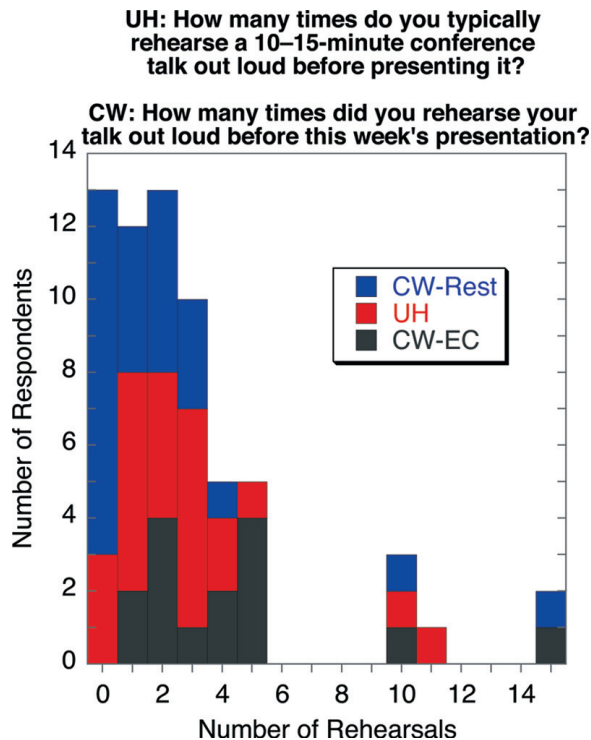


FIG 3. Number of UH respondents to the question “How many times do you typically rehearse a 10–15-minute conference talk out loud before presenting it?” and number of CW respondents to the question “How many times did you rehearse your talk out loud before this week's presentation?”

PERCEPTIONS ON WRITING WITHIN THE UH GROUP. I asked these next three questions of the UH group to see how I could better focus the content of the course. As discussed in Schultz (2010c), even with the strong focus of writing in the course, many of the students indicated in the week-14 evaluation that they wanted even more writing as part of the course.

UH: 22) What do you feel are your biggest challenges in writing a scientific manuscript?

- English 7
- Starting the project/beginning 6
- Clear text 4
- Don't know scientific field /weak knowledge of science/references 3
- How to present results 2
- No time to write 2
- Most important issues and motivation 2
- Keeping short while telling important facts/being concise 2
- Focusing argument 1
- Not knowing what is publishable 1
- Lack of support from job for publishing 1
- Write longer 1
- Following structure without repeating information 1
- To say the things in my head understandably 1
- Introduction/conclusion/discussion 1
- Logical structure 1
- Maintaining exactness and readability 1
- To attain to what I show and not to what I'd have shown 1

UH: 23) What do you feel are your biggest weaknesses in writing using the English language?

- Vocabulary/not knowing the right words 7
- Sentences: structure, too long, too complex 6
- Grammar 4
- Writing fluently/style 3
- Stating things clearly 3

TABLE 1: Responses to the question, "What order do you typically read a scientific article?" Number of respondents who ranked each section of the paper in a particular order. Bold-faced values represent the maximum value in each column; italicized values represent the secondary maximum or maxima. Numbers in each column or row may not add up to the total number of respondents (74) because not all sections were ranked by all respondents.

Rank	Title	Abstract	Introduction	Figures	Tables	Data/methods	Results	Discussion	Conclusions
1	73							1	
2		70		3		1			
3		1	34	13	1	3	1	1	20
4			12	19	8	11	8	2	12
5			6	18	<i>12</i>	12	18	8	7
6			3	9	<i>12</i>	11	13	<i>17</i>	7
7			8	4	<i>12</i>	12	<i>16</i>	12	8
8		1	3	4	10	10	13	22	3
9	1	2	8	1	14	12	3	11	<i>16</i>

Language skills and inexperience 2
 Transition 2
 Punctuation 2
 Articles (the/an/a) 1
 Too simple language 1
 Spelling 1
 Prepositions 1
 Not knowing what to say 1
 “Redundant fluff” 1

UH: 24) *What resources do you use when you need help writing your scientific articles (e.g., more experienced coauthors, other classes at the university, writing center, Web pages, colleagues)?*

Coauthors 17
 Colleagues/professors 10
 Literature 4
 Web pages 3
 Supervisor/group leader 3
 Dictionary 2
 Student friends/peers 2
 Husband (or other native English speakers) 2
 Google 1
 Reviewers 1
 Style guides 1
 Brother (physicist) 1

ORDER OF READING AND WRITING A SCIENTIFIC ARTICLE.

25) *What order do you typically read a scientific article? Place a number (1–9) under each section.*

Title, abstract, introduction, figures, tables, data and methods, results, discussion, conclusion

26) *What order do you typically write a scientific article? Place a number (1–9) under each section.*

Title, abstract, introduction, figures, tables, data and methods, results, discussion, conclusion

TABLE 2: Responses to the question “What order do you typically write a scientific article?” Number of respondents who ranked each section of the paper in a particular order. Bold-faced values represent the maximum value in each column; italicized values represent the secondary maximum or maxima. Numbers in each column or row may not add up to the total number of respondents (69) because not all sections were ranked by all respondents.

Rank	Title	Abstract	Introduction	Figures	Tables	Data/methods	Results	Discussion	Conclusions
1	17	4	8	20	2	18		1	1
2	4	5	10	14	18	9	10		
3			12	17	9	17	15	1	1
4	1	2	8	6	19	14	13	6	1
5	3		10	5	4	5	16	22	5
6	3		7	2	6	5	7	23	16
7	6	6	10		5	1	5	9	27
8	16	24	5	3	2		1	7	9
9	19	28		1	3				9

These two questions were asked to gauge how authors read and wrote articles. The results are presented in Tables 1 and 2, combining all three groups to improve the results. Schultz (2009, section 4.2) describes nonlinear reading, where most busy people will read by skipping around through the manuscript to the parts that are most interesting to them. Respondents will read the title and abstract first, then proceed on to the introduction or conclusions, the figures and the interior of the manuscript, leaving the discussion, tables, and data/methods toward the end (Table 1). Fourteen of the 74 people who responded read an article straight through (including several that omit some parts).

In contrast, respondents tend to create the figures and write the data/methods first, followed by the introduction, body of the paper, and conclusions, ending with the title and abstract (Table 2). Although, a few authors will write the title first (Table 2). In contrast, only 4 of the 69 respondents will write the paper straight through from title to conclusions (perhaps excluding the figures and tables).

ACKNOWLEDGMENTS. I thank the students of the University of Helsinki course “Communication Skills for Scientists” and the attendees of the 14th Cyclone Workshop who answered the surveys. I also thank John Gyakum and Lance Bosart for allowing me to distribute the surveys during the Cyclone Workshop, and Paul Croft and the two anonymous reviewers for their comments. Partial funding for Schultz comes from Vaisala Oyj.

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