

How to Help Students Improve Their Skills in Scientific Writing

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Today, educators are concerned about the writing skills exhibited by many high school and college students. This concern was common at the high school level twenty years ago; it may be even more common and more valid today. Because many students demonstrate little or no motivation toward academic endeavors, we must work very hard to help students improve communication skills in general and writing skills in particular.

J. J. Lagowski, in the *Journal of Chemical Education* (8), noted, "... scientists and humanists share a common concern over the deterioration of the educational processes as reflected in the well-documented decline of high school seniors' reading and writing skills since the 1960's." He also mentioned a recent national survey which reveals, "the number of remedial classes in English, both grammar and composition, and mathematics increased by 22% in colleges and universities during the 1980-81 academic year."

Technical writing, in the broadest sense, is factual, non-fictional writing. It includes writing about scientific matters for other scientific specialists. Examples may be found in *Cell Biology*, the *Journal of Heredity*, and the *Journal of Inorganic Chemistry*. This type of technical writing is called scientific writing, while science writing is that addressed to the general public. Science writing should, therefore, be less technical than scientific writing. Finally, when we speak of material written for engineers about engineering matters, we speak of technical writing in its narrowest sense.

Many scientists and engineers receive no formal instruction in scientific or technical writing at the post-secondary level. While some professionals write better than others, all can improve. Those who write better advance more rapidly in their profession. Teachers can help future scientists and engineers to do a better job of writing, but they must work at it continuously.

This problem is described very well by C. G. Enke (6) of the Department of Chemistry at Michigan State University who wrote,

"It is difficult to overemphasize the importance of writing in the professional life of a scientist. The amount of the time my colleagues and I spend writing is out of all proportion to the fraction of our training devoted to developing writing skills. Publish or perish is a cliché, but it carries the unmistakable implication that experimental work and elegant theories have no peer value until they have been put in manuscript form. I was shocked to find that the time and effort of writing was often equal to that of the research work being described. In addition to research papers, I am continually involved in writing proposals, reports, course syllabi, laboratory experiment instructions, letters of recommendation, manuscript reviews, book reviews and books. This is the common experience of academic scientists and the tasks of writing fall heavily on industrial scientists as well."

Robert Barrass suggests, "Science teachers should help in teaching English by telling young scientists *why* they need to write and *how* they should write.

Children will not appreciate the importance of writing in all their school work if the teacher of English is the only one who corrects errors in grammar" (1). When I taught high school biology, my students often asked why I worried about their grammar because I was not an English teacher. I tried to convince my students that grammar and spelling are important in all fields. A few have since told me my efforts were helpful.

In writing about the problems faced by college instructors who stress the need for skill in written communication, Davis and Matlak (3) noted that students do not realize that they face a more rigorous review of their work in science classes than in many other disciplines. They say, "The critical, testing attitude implicit in science predisposes the science audience to attack any written work which lacks organization and clarity. Words which do not directly enhance clarity or communicate information are viewed as superfluous. In essay exams, information which was not asked for generally costs the student grade points." When this happens repeatedly, students may withdraw and learn to dislike the rigorous courses. They tend to take the path of least resistance which may haunt them and society for the rest of their lives. In an age of increasing dependence upon science, technology and communication, we can ill afford to perpetuate such a situation.

The greatest discovery in science is nothing until it has been reported to the scientific community and verified by another individual or group. Thus, communication, especially precise writing, is very important to a scientist. It is essential that the reader recognize an orderly progress "from inference to hypothesis to evidence to generalization" (10). Yet, many editors of scientific journals have observed that a great number of scientists today are in need of improved writing skills. According to DeBailey, "Only the rare scientific manuscript requires no changes at all. Minimal changes consist in making the manuscript conform to the editorial practices of the journal regarding spelling, symbols, abbreviations, hyphenation, capitalization, punctuation, nomenclature, format for citations of references, and other mechanical considerations, which may be detailed in the copy-editing manual of the journal or publisher" (5).

Also, Barrass has noted, "It is not enough to teach scientists about science. We must also help them to be effective as scientists. And there is a certain irony in teaching students of science and engineering to use techniques and instruments, some of which they may never use in their working lives, and yet not teaching them to write—the one thing that they must do every day as students, and as administrators, executives, managers, scientists and engineers" (1).

According to Justin Leonard, "The Ph.D. in science can make journal editors quite happy with plain, unadorned, eighth-grade level composition" (9), while Robert A. Day suggested, "In scientific writing, we say, the best English is that which gives the sense in the fewest short words" (4).

Some of the common errors in writing are described by Barrass (1). Only a few of those errors are treated here:

A. Terms frequently misused—

alternatively	for alternately
either	for each (or both)
except	for unless
generally	for usually
major	for great
minor	for little

- | | |
|---------|-------------|
| several | for some |
| weather | for climate |
- B. Unnecessary qualification of words—
- | | |
|--------------------|-----------|
| absolutely perfect | perfect |
| almost perfect | imperfect |
| conclusive proof | proof |
| few in number | few |
| small in size | small |
| quite obvious | obvious |
| hard evidence | evidence |
| raw data | data |
| very relevant | relevant |
- C. Circumlocution—
- | | |
|---|-------------------------|
| In virtually all sectors of the environment . . . | Almost everywhere . . . |
| I myself would hope . . . | I hope . . . |
| on a regular basis | regularly |
| It was observed in the course of the demonstration that . . . | We observed . . . |
- D. Lack of precision—
- approximately means very closely (not about or roughly)
 - data (plural) refers to facts such as measurements recorded as numbers
 - results are obtained by the analysis of data
 - significant is a precise statistical term; it should not be used in other contexts
 - infer is what a reader or listener may do; the writer or speaker implies
 - comprise (not comprised of)
 - different from (not different to)
 - superior to (not superior than)

Peterson (10) noted, "The relationship of scientific logic to scientific writing is considered in terms of organization. Good organization, not only of the whole report but of all the parts, is the key in good writing." He continues, "When an author sits down to write a journal article, his first task is to visualize and construct a logical pattern or design that he can follow . . . [This design] can be made evident by the skillful use of the rhetorical techniques of outlining, paragraphing, topic sentences, and 'binding words'." Joanna Freeman noted, "Certain characteristics of effective writing are always desirable in every type of technical writing: correct grammar, punctuation and spelling, clear organization, and a direct style" (7).

Many fine sources are available to aid you and your students as you work to improve your writing skills. Some of these sources are identified in the bibliography by Cory (2).

Robert Barrass (1) suggested the following rules for effective communication:

1. Always decide what you wish to say, why you wish to say it, and whom you hope to interest, before you start to write.
2. Write of things you know, if you have something interesting to say.
3. Plan your work so that information and ideas can be presented in a

logical and *effective* order, and so that the whole composition has the qualities of balance and unity.

4. Write for easy reading. Begin well. Keep to the point, be *clear*, direct and forceful. Maintain the momentum of your writing to the end. End effectively."

You should then revise your work two, three, or more times.

Robert A. Day (4) managing editor of the American Society for Microbiology for nineteen years and now director of ISI Press, a subsidiary of the Institute for Scientific Information, recommends you consider these four questions, in order, as you prepare a scientific paper:

1. What is the problem? (Your answer is the INTRODUCTION)
2. How did you study the problem? (Your answer is the MATERIALS AND METHODS section)
3. What did you find? (RESULTS)
4. What did your findings mean? (DISCUSSION)

Next, add a SUMMARY and list your REFERENCES (or LITERATURE CITED). Some editors prefer an ABSTRACT of about 200-250 words including principal objectives, scope of investigation, methodology, results and principal conclusions instead of a summary.

Day suggests ten points for reviewers. Writers should evaluate their writing before submitting it to a publisher in the light of these same points:

1. Importance of the subject studied
2. Originality of the work
3. Appropriateness of the experimental design
4. Adequacy of your experimental techniques
5. Soundness of your conclusions and interpretation
6. Relevance of your discussion
7. Soundness of the organization
8. Adherence to the appropriate style manual
9. Appropriateness of the title, and
10. Appropriateness for the journal to which it is being submitted.

Teachers can be most useful to students if we improve our own writing skills. But there is no short-cut to good writing. If you wish to improve as a writer, you must write, have your work evaluated, then write and write some more. You should also submit an article or a book review to a journal such as the *Journal of College Science Teaching*, *The American Biology Teacher*, *The Hoosier Science Teacher*, *The Science Teacher*, *The Physics Teacher*, or the *Journal of Chemical Education*. You will enjoy sharing your ideas with others. Such sharing can be very rewarding!

In summary, we have major deficiencies in scientific and technical writing among scientists and engineers today. As educators, we often do not prepare these people adequately for this very important aspect of their professional lives. In this article, suggestions are provided by which teachers can help students to improve their writing skills. If you feel this area is important, you should impress upon your students the importance of learning to write with clarity, precision, and economy in a style which will prove interesting to the intended audience.

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