

The Craft of Scientific Writing

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Michael Alley

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◆
For Karen
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Preface

Most people do not realize that writing is a craft. You have to take your apprenticeship in it like anything else.

—Katherine Anne Porter

As an engineer or scientist, your writing affects not only how much credit you receive for your work but also how much influence your work has. In effect, the quality of your writing influences decisions by others on whether to hire you, to fund your ideas, or to publish your findings.

No doubt, in your schooling, you have taken courses on writing. As an engineer or scientist, you certainly will draw on those courses because they provide you the foundation of your craft. However, scientific writing poses challenges that general writing courses do not cover. First, the subject matter of scientific writing is significantly more complex. From the design of an artificial limb to the distillation of crude oil, the content of science is more specific, unfamiliar, and mathematical. Second, the type of audience varies much more in scientific writing than it does in general writing. In one scientific document, you might target experts in a field. In another, you might address politicians who have never taken basic chemistry or physics. Still a third challenge of scientific writing is that you as an author have to confront stylistic choices that you did not see in general writing courses: how to divide documents into sections, how to distill a large project into a concise summary, or how to integrate illustrations and equations with text.

The goals of this book are not only to help you meet those challenges but also to raise your scientific writing to the highest

level. To do so, this book provides insights that are specific to scientific writing:

Analyze not only what your audience knows, but also why they are reading.
Keep things as simple as possible, yet no simpler.
Begin with what is familiar before moving to what is new.

To anchor such insights, this book provides scores of examples from engineers and scientists around the world. In essence, these examples show you the differences between strong scientific writing and weak scientific writing. What distinguishes this book from the host of technical writing books on the market is that this book dives below the surface question of how engineers and scientists typically write scientific documents to the deeper question of how you should write your scientific documents. In other words, rather than spending hundreds of pages to show you the many stylistic ways that scientific documents are written, this book focuses only on the most effective strategies.

At this point, a fair question is what qualifies me to pass judgment on what is strong scientific writing and what is not. First, I was educated both as an engineer (master of science in electrical engineering) and as a writer (master of fine arts in fiction writing). Second, in the past 30 years, I have written and edited many engineering and scientific documents. Third, I have taught writing to thousands of engineers and scientists at respected institutions on four different continents and in seventeen different countries. Examples include AREVA Nuclear Power, the Army Corps of Engineers, Battelle Memorial Institute, the European Space Organization, Lawrence Livermore National Lab, Pennsylvania State University, Qatargas, Sandia National Laboratories, Shanghai Jiao Tong University, Simula Research Laboratory, the University of Sao Paulo, and Virginia Tech. The insights, questions, and challenges of engineers and scientists at those institutions have shaped, molded, and refined the advice in this book. In effect, those engineers and scientists have served as this book's editors.

Although this book focuses on effective styles in scientific writing, you should not assume that this book teaches you to write in a paint-by-numbers scheme. In science and engineering, the wide variety of audiences, purposes, and occasions precludes such an approach. Rather, this book makes you a critical reader of scientific writing so that you can craft a style for your situation. In addition, because you have only so many hours a week to devote to writing, this book dissects the ways that professional writers put words and images onto paper. In doing so, the book provides practical advice to make you more efficient at all four stages of the writing process: preparing, drafting, revising, and finishing.

I wish that this book would make your scientific writing easy. Unfortunately, scientific writing is hard work. The best scientific writers struggle with every paragraph, every sentence, and every phrase. They write, then rewrite, and then rewrite again. Scientific writing is a craft, a craft you continually hone.

University Park, USA
February 2018

Michael Alley

Acknowledgments

More than 40 years ago, my sixth-grade English teacher, Mrs. Hutton, drilled into my classmates and me an understanding for the parts of speech and how those parts combine into proper sentences. At the time, I did not appreciate Mrs. Hutton's efforts. Instead, I did the homework that she assigned and answered the questions that she posed in class, all the while fearing her reprimands and relishing her praises. To this day, I draw on her lessons every time I sit down to write.

Writing is not mastered in a single course. Looking back on my career, I am indebted to other teachers who insisted that my writing be clear, connected, and correct: Mrs. Anderson (9th grade English, St. Genevieve's of the Pines), Mr. James B. Fischer (Latin, The Asheville School), and Margaret Morgan (freshman composition, Texas Tech University). All of these teachers deepened my foundation for putting together clear and precise sentences and for connecting those sentences into coherent paragraphs.

Sadly, about 30 years ago, a misguided education movement in the United States seduced many writing instructors into no longer formally teaching the grammatical foundation of the English language. Instead, the movement, which aimed to make writing fun, relied on less taxing assignments such as first-person stories and *I believe* essays. An unfortunate result is that many young engineers and scientists today, as gifted as they are, do not have a firm grasp of what a sentence is, what it is not, and what it can be. In scientific writing, such a foundation is essential for crafting sentences and paragraphs that inform and persuade. Although this book does not cover

everything that my writing teachers taught, this book distills their lessons into what applies most in scientific writing.

In addition to writing teachers who taught me the core principles of writing, I owe much to the many scientists and engineers who have shared their insights on scientific writing and editing. Foremost, I would like to thank my amazing wife, Prof. Karen Thole. Her successes not only as head of one of the largest engineering departments in the country but also as a leading researcher in gas turbine engines and mentor to more than 70 graduate students have provided many of the strong examples in this text. In addition, her energy, vision, and pursuit of excellence in her work have inspired me to aim higher in my own.

Much is also owed to the late Harry Robertshaw. For 7 years, the two of us interwove principles of measurements and writing into a laboratory course taken by hundreds of mechanical engineers at Virginia Tech. What that experience taught me is that even in large courses, you can continue the writing education of each student. The effective teaching of writing boils down to four steps: (1) providing insights to students on how to communicate the course's content, (2) having the students apply those insights in a meaningful document, (3) supplying feedback on that document, and (4) having the students use that feedback to revise.

Over the past 15 years, many of my best insights into scientific writing have arisen from working with Are Magnus Bruaset and the late Hans Petter Langtangen, both with Simula Research Laboratory. In particular, these two have strongly shaped this book's ideas about writing proposals. In addition, I would like to thank the following writing teachers who have influenced and inspired me on particular passages of the book: Christine Haas, Jean-luc Doumont, Christy Moore, D'Arcy Randall, Hillary Hart, Lesley Crowley, Warren Goldstein, and Brad Henderson. Moreover, deep thanks go to my parents—both chemists who instilled in me a love of science, nature, and reading.

My greatest debt, though, I owe to the students in my university courses and professional workshops. In particular, I would like to thank those from Penn State, Virginia Tech, the University of Oslo, Shanghai Jiao Tong University, the University of Wisconsin–Madison, the University of Texas at Austin, Simula Research Laboratory, AREVA Nuclear Power, Lawrence Livermore National Laboratory, and Sandia National Labs. You have challenged my advice, revised it, and made it more precise.

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Introduction

The greatest merit of style is to have the words disappear into thought.

—Nathaniel Hawthorne¹

When you as an engineer or scientist sit down to write, you make hundreds of decisions. Some are large, such as which details to emphasize. Other decisions are much smaller, such as whether to insert a comma after an introductory phrase. Although smaller, many such decisions occur so often that they deserve attention. No matter whether large or small, all decisions about writing fall under one of three categories: content, style, or form.

Content is *what* you wish to convey. In scientific writing, content varies widely—from experiments on atomic particles to theories about solar galaxies. Although essential for the success of scientific writing, content is not the focus of this book. Rather, an assumption in this book is that you have valuable content to convey.

Style, on the other hand, is *how* you convey the content to the audience. For example, style includes the ways in which you cast your ideas into sentences and how you connect those sentences into paragraphs. Style also concerns how you combine those paragraphs with illustrations to create sections and how you arrange those sections into documents. The first nine lessons of this book focus on achieving an effective style in scientific writing.

¹Adapted from Nathaniel Hawthorne (1951), letter to an editor, <https://www.thoughtco.com/plain-style-prose-1691632>.

Form then consists of the writing rules that readers expect you to follow, such as how to use a colon properly, when to write out a number, or the guidelines for inserting a reference listing into the text. Many such rules are universal. For instance, with only a few exceptions, the rules for *grammar*,² punctuation, and *usage* are the same in Seattle as they are in Sienna or Shanghai. Appendices A, B, and C focus on the rules of grammar, punctuation, and usage that cause the most problems for engineers and scientists. Other rules are local—such as guidelines for *format*, which comprises the typography and layout of a document. In most cases, the format that you select for a document depends on the publication or institution. However, for those situations in which you have to design the format, Appendix D presents guiding principles for achieving a professional look.

While the perspectives of content, style, and form help you decide which words and images to select, another important perspective is you, the writer. More specifically, what is your process for placing those words and images onto the page? As an engineer or scientist, because you have only so many hours each week to devote to writing, the time that you spend writing should be efficient. Drawing on the advice of professional writers, Lesson 10 in this book analyzes the four stages of sitting down to write a document: preparing, drafting, revising, and finishing.

²Terms in boldface italics are defined in the Glossary.