

# Tips on Scientific Writing and Manuscript Preparation

By Cristian A. Linte

**T**echnical communication entails conveying information about a technology to intended audiences in different fields, including science, engineering, biotechnology, and medicine, often in the form of publications and technical papers. The purpose is to disseminate the intended information in a useful manner, enabling the reader to fully comprehend the content. If a document fails to communicate the information efficiently so that the reader can understand, then the communication is meaningless. Writing well is labor intensive and often difficult, and technical subject matter further compounds these difficulties. Poor writing will erode readers' confidence in a paper; hence, to accomplish the intended goals, a paper must follow a logical development and be professional in content, written in formal language, and properly formatted.

## Journals Versus Proceedings

Given their extensive peer review, journal papers are considered more prestigious and of better quality, which is a necessity for academicians. Moreover, they will be archived, with access limited by subscription, accessed by many experts in the field, and will have a greater chance of being cited given broader exposure. Nevertheless, the publication process may take anywhere from six to 24 months from the date the paper is submitted for review until it appears in the journal, if accepted for publication.

Conference proceedings, on the other hand, have less exposure than work published in journals, and, although they are

peer reviewed, depending on the publisher, they may or may not be archived or indexed. Nevertheless, the publication process is not as involved—the acceptance rate is typically higher than for journals, and the work is published much more quickly.

If you are interested in quickly disseminating a work in progress, you should probably aim for a conference presentation and publication in conference proceedings and plan to follow up with a full-blast publication in a high-impact journal once the work has matured.

## Manuscript Organization

Although all published papers follow a typical structure—front matter, body of paper, and end matter—most readers only briefly skim through a paper in an order more or less similar to the following: title and author list, abstract and keywords, figures and captions, section headings, conclusions, equations, and certain portions of the text. Therefore, you should make sure these elements are well crafted: the last figure and the conclusions clearly reiterate the take-home message, which is also clearly stated and emphasized throughout in the title of your work, the abstract, and at least three times in the main body—introduction, results or discussion, and conclusion.

The title is the first and most visible part of your paper. A well-selected title concisely describes the main theme of the work presented in the paper and

grabs the readers' attention in 12 words or fewer. The title does not need to be an abstract—it distracts the reader as does the use of acronyms, which should also be avoided in titles. The abstract is the second-most-read part of a paper, and it should concisely summarize the contents of the paper in 200–250 words or fewer.

The substance of the hard work falls into the body of the paper. The introduction sets the stage for the paper: it familiarizes the reader with the context of the paper, provides a brief background on the topic while referring to previous work, states the motivation of the proposed work and how it addresses the limitations currently encountered, and provides a brief outline.

The methodology section is organized according to various section headings and subheadings. Make sure that you describe all methods and materials employed to enable other researchers to reproduce your work. Incomplete experimental methods and partially described techniques will only get you an exhaustive reply from the reviewers on how your work is not well documented, irreproducible due to lack of experimental detail, and not publishable in its current state.

If the work is based on physical or mathematical models described by equations and formulas, include only the most significant ones in the body of the paper and save the detailed derivations for the appendices, in the end matter. Number equations accordingly, incorporate them as part of the sentence, and refer to them in the text. Also, don't forget to state the assumptions or limitations under which the equations are valid and always strive to provide a physical interpretation of the mathematical formulas in the text.

The findings of the research study are usually presented in the results section, accompanied by the appropriate validation

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and statistics often required to support your claims in an engineering/scientific manner. The discussion section is where the results are reviewed as a whole in the context of the broader field and compared to initial predictions, objectives, or hypotheses.

The conclusion section wraps up the paper with a succinct summary of the work, relating the findings to the general problem, indicating the implications of the work in the field, and suggesting possible follow-up works.

It is important to not hyperbolize your findings and over extrapolate the conclusion beyond what the results support; it usually annoys most reviewers and may lead to exhaustive comments or even rejection of the paper for not having addressed all those aspects.

The end matter consists of auxiliary material, but it is essential to the paper. Credit those who helped by providing funds; performing the experiments; writing the manuscript; or providing technical support, clinical expertise, and editorial assistance. The bibliography is also included in the end matter, and its format is usually dictated by the publisher. Cite foundational or background work, list sources of information and techniques, avoid plagiarism by including all sources of information, and give credit where credit is due.

## Figures and Tables

After the title and abstract, the figures and diagrams are the next most important parts that readers will aim for when browsing your paper. A picture is worth a thousand words, so support your text with thoughtfully constructed diagrams to help explain concepts that may otherwise require wordy paragraphs. Figures and tables should appear distributed throughout the paper and must be referenced in the text by a figure or table number. Each figure and table must be accompanied by a caption that is sufficiently detailed to describe the information without the need to read the text.

Make sure that all lines, axes, labels, legends, and symbols are large enough to

ensure their legibility in the final version. Also, use color appropriately, and check whether the final version appearing in the journal will be printed in color. Hard copies are subject to additional costs for color printing, but, nevertheless, color figures will be preserved (for free) in the electronic version of the article. To avoid confusion, it is best to plot data using solid, dashed, or dotted lines and various data symbols instead of color and not refer to a color scale that may appear as a gray scale in the printed versions.

## Writing the Manuscript

Once you have performed all the experiments and collected and analyzed all data, you are ready to start writing the manuscript. But first, plan it out: determine the scope of the communication, identify the main objectives and what you want to convey, and identify your audience. Don't rush to write the full-blown paper; start with an outline and keep in mind the standard paper organization, its logical development, all figures and tables, and how they support the text. If you have collaborators, this is the best time to get them involved, have them share their ideas with you, brainstorm on what should or should not be included in the manuscript, and assign them writing tasks. After finalizing the outline, check once again for the logical sequence of topics.

Write your first draft based on your outline without worrying too much about spelling and style. To avoid disappointment by writer's block, start with the sections that are easiest to write, put down key phrases, and later develop them into full sentences. It helps to stay focused by setting aside 1–2-hour blocks of time for writing, establishing goals for what should be achieved during each writing session, and taking a break once you have full sections completed. An environment that is conducive for writing also helps and, if severely blocked, change the scenery—leave the lab and go home or to the library where you can be more efficient.

Slowly but surely, you'll have a draft in a few days, which you can then revise

and see if the paper is really what you want. Although most of us are e-savvy these days, printing out the paper old-style and editing the paper with a pencil is not overrated. Quite the opposite in fact; it lets you look at the paper as a whole, rearrange sections and subsections to maintain flow, identify what is missing and add new text, as well as check for style and proper English, sentence construction, word choice and usage, grammar, punctuation, and spelling.

## Writing Style

A good writing style is imposed in the revision process, and it gives the overall clarity, conciseness, and coherence of the paper. To make the paper more appealing to the reader and increase its appearance, organize each section in paragraphs. While each paragraph may comprise 10–15 lines of text, for the sake of diversity, vary the paragraph length to slightly break the monotony and break up those that are too long.

Simple sentence structure promotes clarity and readability. Compound sentences are fine, as long as they are straightforward and not too long, and can be useful to provide variety and define relationships between ideas. In general, sentences should not run on, but their length should be varied to break the monotony.

Although it may seem unnatural to write about the past in the present, present tense can be used along with other tenses: past tense may be used to refer to work previously done by others, work that you, the author, did for the paper (e.g., conducted specific experiments), or when referring to earlier sections in the paper. Similarly, future tense may be used to refer to later sections in the paper or when outlining your future research endeavors.

## Common Writing Problems

One common problem in technical writing is the appropriate use of active or passive voice. In active voice, the subject acts, while in passive voice, the subject is acted upon. Often, active voice is preferred as it generally improves clarity and reduces ambiguity and wordiness.

Beware of the appropriate use of definite and indefinite articles; writers whose first language is not English often tend to

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omit their use. Also, avoid treating countable nouns as uncountable (e.g., ten items or fewer *not* ten items or less—tell that to the grocery store manager next time you go shopping), as well as the inappropriate use of words such as *what*, *that*, and *who*. Avoid the use of *this* at the beginning of a sentence with no following noun, as it often indicates an ambiguous reference (e.g., *This result means that* instead of *This means that*).

A few other common writing mistakes include inappropriate use of jargon, depending on the expertise of the audience, abusive use of acronyms, which tend to irritate the reader if used too often, as well as inappropriate use of punctuation. An excellent reference on how to appropriately use punctuation and grammar is Strunk and White's short book *The Elements of Style*.

### Word Choice and Usage

Avoid ambiguity by carefully choosing powerful words with definite meanings to convey the information you want. If unsure of the meaning of a word, check the dictionary for the correct meaning or use a thesaurus to find the most appropriate words to express your idea. Don't try to impress the reader with words that you don't know as they may not be appropriate in a specific context. To avoid redundancy, keep your paragraphs concise, streamline your text by removing unnecessary words, eliminate wordy phrases, and avoid the use of ornate or erudite words.

Colloquial language often used in casual conversations should not be used in technical writing. Avoid slang, which is informal and faddish, and shoptalk—jargon used by you and your colleagues at the local pub on Friday afternoon—"that gizmo" may mean something to you, but not to others.

### Tools for Manuscript Preparation

The most common document processor is probably Microsoft Word, the well-known, full-featured, word processing software available as part of any Microsoft Office package. Microsoft Word integrates a spelling and grammar checker

and is compatible with other Microsoft Office products often used for data analysis and preparation of figures and tables. Similar features are available in OpenOffice, an open-source package available free of charge.

A more powerful tool for technical document and manuscript preparation is LaTeX, currently employed by many authors and accepted by most publishers. In fact, specific LaTeX templates for many journals and conference proceedings can be downloaded from the publisher's Web

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site. LaTeX is available free of charge for all operating systems (Windows, Linux, and OS-X). Its numerous features include excellent equation formatting (enhanced mathematical capabilities that follow the standards of the American Mathematical Society), au-

tomatic numbering of section headings, subheadings, figures, and equations, and easy citation and referencing, while enforcing publishing rules and manuscript formatting. In addition, LaTeX also offers the flexibility of converting the output manuscripts to a standard document format (.ps and .pdf).

If you are not familiar with LaTeX, give it a try for your next paper. You'll be so impressed by all of its features that you will never consider preparing your next dissertation using any other manuscript preparation package.

### In Conclusion

Technical writing is not just simple writing but rather a unique and very distinguishable skill. It can be learned and mastered, but it requires time, hard work, and practice. However, once developed, the techniques of technical writing are useful in preparing research grants and scholarship applications, technical presentations, and even Web pages.

As a technical writer, you must always strive for clarity, conciseness, and coherence. If you keep in mind these three objectives when preparing your next paper, you will succeed in presenting the complexity of your research in a way that makes it easy for the reader to understand the concepts, extract the key information, and give you the credit you deserve.

Best of luck with the preparation of your next manuscript! If you have any questions or comments, feel free to contact me at [clinte@mail.rit.edu](mailto:clinte@mail.rit.edu).

I would like to thank Dr. Kenneth Hanson (Los Alamos National Laboratories) for his excellent course on technical writing in medical imaging, parts of which I have used as references in this article, offered annually at the SPIE Medical Imaging Symposium—try to attend once; it's definitely worth it!

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