GUIDELINES ON WRITING A GOOD PAPER FOR THE *PROCEEDINGS OF THE WINTER SIMULATION CONFERENCE*

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ABSTRACT

Useful guidelines on technical writing are outlined as an aid to authors who are seeking to improve the clarity and readability of their papers in the *Proceedings of the Winter Simulation Conference*. Up-to-date and classic references are provided for each topic, including the available hyperlinks for those references.

1 OUTLINE OF KEY CONSIDERATIONS

Writing a clear, readable exposition of complex technical work is at least as difficult as doing the work in the first place. Given below is an outline of important considerations to keep in mind while you are planning and writing a paper that will be reviewed for presentation at the Winter Simulation Conference (WSC) and publication in the WSC proceedings. For questions about these guidelines, please send an email message to jwilson@ncsu.edu or the proceedings editors.

I. Plan the paper before beginning to write.
   A. Analyze the situation—that is, the problem, the solution, and the target audience.
      1. Formulate the objectives of the paper.
      2. Specify the paper's coverage of the subject and the results to be discussed. Orient the paper toward the theme of your session as indicated by either the title of your session or the instructions of your session chair. Also take into account the focus of the entire track, which could be education (for introductory, advanced, and vendor tutorials); theory and methodology (for modeling and analysis tracks); case studies; domain-specific applications; or general applications.
      3. Identify the target audience and determine the background knowledge that you can assume for this group of people. Introductory tutorials are generally attended by newcomers who are interested in the basics of simulation. Advanced tutorials are designed to provide more experienced professionals with a thorough discussion of special topics of much current interest. Methodology sessions provide state-of-the-art information on proven techniques for designing, building, and analyzing simulation models; and those sessions are attended by professionals who have at least an undergraduate-level background in computer simulation techniques. In the case studies and applications tracks, session attendees are generally familiar with the area covered by their session. Vendor tutorials attract both new and experienced users of the relevant software products.

B. Formulate the most logical sequence for presenting the information specified in item 2 to the readers identified in item 3. For a discussion of effective aids in organizing your paper—specifically, brainstorming, wordstacks, concept maps (clustering), issue trees, outlines, and figure shuffling—see Heard (2016, chap. 7); Matthews and Matthews (2014, chap. 3); Pearsall and Cook (2010, chap. 3); Flower (1981, chap. 1); or Menzel, Jones, and Boyd (1961, chap. 1).

1. Plan the introductory paragraph(s).
   a) Seize the reader's attention immediately in stating the problem to be solved.
   b) Summarize briefly the main results and conclusions.
   c) Tell the reader how the paper is organized.
2. Plan the body of the paper.
   a) Include enough detail in the body of the paper so that the reader can understand what you did and how you did it; however, you should avoid lengthy discussions of technical details that are not of general interest to your audience.
   b) Include a brief section covering notation, background information, and key assumptions if it is awkward to incorporate those items into the introductory paragraph(s).
   c) Include sections on theoretical and experimental methods as required.
      - For an application paper, you should discuss the development of the simulation model, including input-data collection as well as the design, verification, validation, and use of the model.
      - For a methodological or theoretical paper that requires substantial mathematical development, see Krantz (2017, chap. 2); Higham (1998, chap. 3); Knuth, Larrabee, and Roberts (1989, 1–6); or Halmos (1970).
      - For standard mathematical notation used in engineering and the sciences, see *ISO 80000-2: Quantities and Units—Part 2: Mathematical Signs and Symbols to Be Used in the Natural Sciences and Technology* (ISO 2009) and Scheinerman (2011).
   d. Plan the results section to achieve the most effective mix of text, figures, and tables in the presentation of your results. Tufte (2001) is the definitive reference on the design of figures and tables.
      - For a comprehensive discussion of figures, see also *The Chicago Manual of Style* (University of Chicago Press 2017, sec. 3.3–3.46); Gastel and Day (2016, chap. 17–18); or the *AIP Style Manual* (AIP 1990, chap. V).
      - For a comprehensive discussion of tables, see also *The Chicago Manual of Style* (University of Chicago Press 2017, sec. 3.47–3.88) or Gastel and Day (2016, chap. 16).
3. Plan the concluding paragraph(s).
   a. Explain how the theoretical and experimental results relate to the original problem. State why these results are important.
   b. Summarize any unresolved issues that should be the subject of future work.
   c. State the final conclusions explicitly in plain language.

II. Write the paper.

A. Select a concise title that accurately summarizes the paper's contribution and stimulates interest in reading the abstract and introduction. For guidance on selecting a title, see Alley (2018, 110–114), Gastel and Day (2016, chap. 7), Higham (1998, sec. 6.3), or Carter (1987, 84–91).

B. Prepare an abstract that is succinct, self-contained, and intelligible to a general reader in the field of simulation. The abstract may not exceed 150 words, and it should not contain any references or mathematical symbols.

1. Summarize the objectives of the paper.
2. Summarize the results and conclusions.
3. State the basic principles underlying any new theoretical or experimental methods that are developed in the paper.
4. For guidance on the preparation of scientific abstracts, see Gastel and Day (2016, chap. 9); *Guidelines for Abstracts* (NISO 2010); the *AIP Style Manual* (AIP 1990, 5); or Carter (1987, 91–93).

C. Write the rest of the paper as though you were talking to a group of interested colleagues about your work.

1. Strive for accuracy and clarity above all else.
2. In writing the introduction, you should remember the following maxim:

> The opening paragraph should be your best paragraph, and its opening sentence should be your best sentence. (Knuth, Larrabee, and Roberts 1989, 5)

You cannot achieve such an ambitious goal on the first try; instead as you add new sections to the paper, you should review and revise all sections written so far. For more on the spiral plan of writing, see Higham (1998, chap. 7) or Halmos (1970, 131–133).

a. Like the abstract, the introduction should be accessible to general readers in the field of simulation.
b. For methodology papers, advanced tutorials, and domain-specific applications, you may assume a substantially more advanced background for readers of the subsequent sections.

3. In constructing each sentence, place old and new information in the respective positions where readers generally expect to find such information.

a. Place in the topic position (that is, at the beginning of the sentence) the old information linking backward to the previous discussion.
b. Place in the stress position (that is, at the end of the sentence) the new information you want to emphasize.
c. Place the subject of the sentence in the topic position, and follow the subject with the verb as soon as possible.
d. Express the action of each sentence in its verb.

For an excellent discussion of the principles of scientific writing based on reader expectations, see Williams and Bizup (2017, 79–92); Williams and Bizup (2015, 44–55); or Gopen and Swan (1990).

4. Make the paragraph the unit of composition.

   a. Begin each paragraph with a sentence that summarizes the topic to be discussed or helps the transition from the previous paragraph.

   b. Provide a context for the discussion before asking the reader to consider new information.

   c. Avoid paragraphs of extreme length—that is, one-sentence paragraphs and those exceeding 15 lines or 300 words; see Alley (2018, 130–131); Higham (1998, 50–51); or van Leunen (1992, 133–134).

   d. Place the important conclusions in the stress position at the end of the paragraph.

5. Allocate space to a topic in proportion to its relative importance.

6. For methodology papers, emphasize the concepts of general applicability that underlie the solution procedure rather than the technical details that are specific to the problem at hand. Supply only the technical details and data that are essential to the development.

7. For application papers, emphasize the new insights into the problem that you gained from designing, building, and using the simulation model.

8. Use standard technical terms correctly.

   a. For standard usage of mathematical terms, see Borowski and Borwein (2002) or James and James (1992). For example, a nonsquare matrix cannot be called "orthogonal" even if any two distinct columns of that matrix are orthogonal vectors.

   b. For standard usage of statistical terms, see Upton and Cook (2014), Porkess (2005), or Dodge (2003). For example, the probability density function of a continuous random variable cannot be called a "probability mass function" or a "distribution function."

   c. For standard usage of computer terms, see the *Dictionary of Algorithms and Data Structures* (Black 1998), *The Free On-Line Dictionary of Computing* (Howe 1993), or Computer Hope (n.d.).

   d. For standard usage of industrial and systems engineering terms, see *Industrial Engineering Terminology* (IISE 2000). For example, the time that a workpiece spends in a manufacturing system may be called "cycle time" or "flow time" but not "throughput time."

9. Avoid illogical or potentially offensive sexist language. See Miller and Swift (2001) for a commonsense approach to this issue.

10. Strictly avoid the following—

    a. religious, ethnic, or political references;

    b. personal attacks;

    c. excessive claims about the value or general applicability of your work; and

    d. pointed criticism of the work of other people.

    Such language has no place in scientific discourse under any circumstances, and it will not be tolerated by the proceedings editors. With respect to vendor tutorials, items c and d immediately above require authors to avoid invidious comparisons of their products with competing products.

11. For each figure, compose a caption (or legend) that explains every detail in the figure—every curve, point, and symbol. Comment explicitly in the text on the significance of each component of the figure.

12. For each table, compose a caption that briefly summarizes the content of the table. Comment explicitly in the text on the significance of the numbers in the table; do not force the reader to guess at your conclusions.

13. In writing the final section of the paper containing your conclusions and recommendations for future work, you should keep in mind the following maxim:

    > The mark of a good summary is revelation: "Remember this, reader? And that? Well, here's how they fit together." (van Leunen 1992, 116)

D. Often it is hard to start writing the paper. In this situation it is usually best to start at a convenient point after the introduction, such as the section on numerical results or the final section on conclusions and recommendations; and the abstract and introduction can be written more easily after the rest of the paper has taken shape.

E. Revise and rewrite until the truth and clarity of every sentence are unquestionable.

1. For questions about the rules of English grammar and usage, see Fowler, Aaron, and Greer (2018); Garner (2016); *Fowler's Dictionary of Modern English Usage* (2015); Strunk and White (2000); *Webster's Third New International Dictionary of the English Language, Unabridged* (1993); the *Oxford English Dictionary* (1989); or Bernstein (1965).

2. For those who use English as a second language, particularly helpful references are Fowler, Aaron, and Greer (2018); Booth (1993); or Huckin and Olsen (1991).

3. For guidelines on how to edit your own writing effectively, see Heard (2016, chap. 21–22) or Cook (1985).

4. For a comprehensive discussion of all aspects of scientific writing, see Alley (2018), Gastel and Day (2016), or Heard (2016).

F. Prepare an accurate and complete set of references that gives adequate credit to the prior work upon which your paper is based.

1. The author-date system of documentation is required for all papers appearing in the WSC proceedings. *The Chicago Manual of Style* (University of Chicago Press 2017, chap. 15) provides comprehensive, up-to-date information on this documentation system.

2. In preparing your list of references, you should strive for accuracy, completeness, and consistency. Using the information provided in your list of references, the interested reader should be able to locate each source of information cited in your paper.

3. For complete instructions on citing electronic sources, see sections 14.6–14.18 of *The Chicago Manual of Style* (University of Chicago Press 2017). For example, sections 14.7 and 14.8 contain basic information on uniform resource locators (URLs) and Digital Object Identifiers (DOIs), respectively; and section 14.18 provides useful rules for breaking a URL or a DOI across two or more lines either in the text or in the list of references. Many examples of citations for various types of electronic sources can also be found throughout chapter 15 of *The Chicago Manual of Style* (University of Chicago Press 2017).

4. The final electronic version of your paper—that is, the portable document format (PDF) file ultimately produced from the Word or LaTeX source file of your paper—may include external hyperlinks referring to some of the electronic sources cited in the paper that are accessible online.

   a. If an external hyperlink is live, then it is colored blue; and when viewing the PDF file of your paper on a computer, the reader can click that hyperlink for immediate

online access to the cited material. More specifically, clicking a live external hyperlink will activate the reader's web browser so that, if all goes well, the cited source of information will be displayed in the web browser. A live external hyperlink may also be used to activate the reader's email software for sending a message to a selected email address; for example, see the hyperlink given in the first paragraph of this document.

b. If an external hyperlink is not live, then it is colored black; and such a hyperlink merely displays the URL or DOI of the cited material without providing immediate online access to that material. To access the cited material in this situation, the reader must copy and paste the URL or DOI into the address bar of a web browser. Alexopoulos et al. (2018a) contains examples of hyperlinks that are not live by design.

c. If you use external hyperlinks in your paper, then you must ensure that the text displayed for each external hyperlink is correct and complete so that a reader who has only a hard copy of the paper can still access the cited material by (carefully) typing the relevant displayed text of the hyperlink into the address bar of a web browser. Remember that your responsibility for the accuracy and completeness of each hyperlink in your paper parallels your responsibility for the accuracy and completeness of each conventional citation of a nonelectronic source; neither the editors nor the publisher of the proceedings can verify any of this information for you.

G. See Wilson (2002) for a discussion of the following ethical and "strategic" considerations in writing a scientific paper that will be considered for publication in a peer-reviewed journal or conference proceedings:

1. achieving a consensus among all relevant colleagues, research assistants, lab assistants, and students on who should be a coauthor of the paper;
2. achieving a consensus among coauthors on the order of authorship in the paper's byline; and
3. writing the paper so as to anticipate and answer key questions that will be asked by the paper's referees and readers.

H. See Alexopoulos et al. (2018b) for an example of a paper that has recently appeared in the WSC proceedings.

III. Cultivate a natural and effective style.

A. Alfred North Whitehead memorably expressed the gist of the matter of writing style:

> Finally, there should grow the most austere of all mental qualities; I mean the sense for style. It is an aesthetic sense, based on admiration for the direct attainment of a foreseen end, simply and without waste. Style in art, style in literature, style in science, style in logic, style in practical execution have fundamentally the same aesthetic qualities, namely attainment and restraint. The love of a subject in itself and for itself, where it is not the sleepy pleasure of pacing a mental quarter-deck, is the love of style as manifested in that study.
>
> Here we are brought back to the position from which we started, the utility of education. Style, in its finest sense, is the last acquirement of the educated mind; it is also the most useful. It pervades the whole being. The administrator with a sense for style hates waste; the engineer with a sense for style economises his material; the artisan with a sense for style prefers good work. Style is the ultimate morality of mind. (Whitehead 1929, 12)

Kurt Vonnegut made the following equally trenchant observation on writing style.

> Find a subject you care about and which you in your heart feel others should care about. It is this genuine caring, and not your games with language, which will be the most compelling and seductive element in your style. (Vonnegut 1985, 34)

Definitive references on writing style are Strunk and White (2000); Williams and Bizup (2015, 2017); and Zinsser (2006).

B. Contrast the following descriptions of an experiment in optics:

   1. I procured a triangular glass prism, to try therewith the celebrated phenomena of colors. And for that purpose, having darkened my laboratory, and made a small hole in my window shade, to let in a convenient quantity of the sun's light, I placed my prism at the entrance, that the light might be thereby refracted to the opposite wall. It was at first a very pleasing diversion to view the vivid and intense colors produced thereby.

   2. For the purpose of investigating the celebrated phenomena of chromatic refrangibility, a triangular glass prism was procured. After darkening the laboratory and making a small aperture in an otherwise opaque window covering in order to ensure that the optimum quantity of visible electromagnetic radiation (VER) would be admitted from solar sources, the prism was placed in front of the aperture for the purpose of reflecting the VER to the wall on the opposite side of the room. It was found initially that due to the vivid and intense colors which were produced by this experimental apparatus, the overall effect was aesthetically satisfactory when viewed by the eye.

   The most striking difference between these two accounts of the experiment is the impersonal tone of the second version. According to version 2, literally nobody performed the experiment. Attempting to avoid the first person, the author of version 2 adopted the third person; this in turn forced the author to use passive verbs. As Menzel, Jones, and Boyd (1961, 79) point out, "Passive verbs increase the probability of mistakes in grammar; they start long trains of prepositional phrases; they foster circumlocution; and they encourage vagueness." Notice the dangling constructions in the second sentence of version 2. Version 1 was written by Isaac Newton (1672, 3076). Even though it was written over 340 years ago, Newton's prose is remarkable for its clarity and readability.

C. Strunk and White (2000, chap. 5) summarize their reminders for achieving a natural and effective writing style:

   1. Place yourself in the background.
   2. Write in a way that comes naturally.
   3. Work from a suitable design.
   4. Write with nouns and verbs.
   5. Revise and rewrite.
   6. Do not overwrite.
   7. Do not overstate.
   8. Avoid the use of qualifiers.
   9. Do not affect a breezy manner.
   10. Use orthodox spelling.
   11. Do not explain too much.
   12. Do not construct awkward adverbs.
   13. Make sure the reader knows who is speaking.
   14. Avoid fancy words.
   15. Do not use dialect unless your ear is good.
   16. Be clear.
   17. Do not inject opinion.
   18. Use figures of speech sparingly.
   19. Do not take shortcuts at the cost of clarity.
   20. Avoid foreign languages.
   21. Prefer the standard to the offbeat.

Reminders 9–13 and 15 above apply to nontechnical writing. For more discussion on the reminders that apply to technical writing, see Menzel, Jones, and Boyd (1961, chap. 5).

2 CONCLUSIONS

Although the foregoing discussion is intended to be a road map for authors who seek guidance on writing a good paper for the WSC proceedings, the discussion should also be useful in writing other types of technical documents such as reports, archival journal articles, book chapters, master's theses, and doctoral dissertations. Perhaps the primary value of this road map is that it provides directions to a substantial collection of classic and state-of-the-art references on technical writing, including complete bibliographic information on each reference so that you can readily access it in electronic or hard-copy form.

As a final consideration, always keep in mind your overriding goal—to communicate your technical contributions accurately, clearly, and forcefully to your intended audience. That requires meticulous planning and intense concentration; but it does not necessarily require slavish adherence to any set of rules for technical writing, including the rules outlined here.

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