

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

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ABSTRACT

Proven guidelines on technical writing are summarized for authors who seek to improve the accuracy and clarity of their papers in the *Proceedings of the Winter Simulation Conference*. Special emphasis is given to effective ways for getting started and building momentum when planning, writing, and revising the paper. Up-to-date and classic references are provided for each topic, including free-access hyperlinks to many key references.

1 OUTLINE OF THE MAIN POINTS

Writing an accurate and clear exposition of complex technical work is at least as difficult as doing the work in the first place. Given below is an outline of the main points to keep in mind while you are planning and writing a paper that will be reviewed for publication in the *Proceedings of the Winter Simulation Conference* (WSC) and presentation at the conference. For most of those points, several alternative references are given to assist you in obtaining additional information if needed; moreover, the associated hyperlinks are to material that can be accessed online free of charge either indefinitely or during a reasonable trial period. For questions about these guidelines, please send email to jwilson@ncsu.edu or the proceedings coeditors.

- I. Plan the paper. ***Getting started is often the hardest part in each stage of any writing project.*** For effective ways to begin planning the paper, see Heard (2016, chap. 7). One good way is to start with task I.B (organizing the paper), which will give you a clearer idea of how to handle task I.A (summarizing the problem, the solution, and the intended audience). At any rate, finalizing the plan for the paper may require several iterations of those tasks. For more details on aids in organizing the paper—specifically, brainstorming, wordstacks, concept maps (clustering), issue trees, outlines, and figure shuffling—see Heard (2016, 62–69); Matthews and Matthews (2014, chap. 3); Pearsall and Cook (2010, chap. 3); Flower (1993, chap. 7); or Menzel, Jones, and Boyd (1961, chap. 1).
 - A. Analyze the situation—i.e., 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 (e.g., introductory, advanced, and vendor tutorials); theory and methodology (e.g., modeling and analysis tracks); case studies; and domain-specific applications (e.g., environment, healthcare, military, and semiconductor manufacturing).
 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 attended by experienced professionals who seek in-depth coverage of high-demand topics. 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 application 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 and services.

B. Organize the paper into a coherent story that conveys the information specified in item I.A.2 to the readers identified in item I.A.3.

1. Plan the introduction.

- a) Seize the reader's attention immediately by stating the specific problem to be solved.
- b) Summarize briefly the main results and conclusions.
- c) Tell the reader how the paper is organized.

2. Plan the other sections of the paper (i.e., methods, results, discussion, and conclusions).

- a) Include enough detail in the other sections 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 the relevant literature, notation, and basic assumptions if it is awkward to incorporate that material into the introduction or the methods section. For standard mathematical and statistical notation used in engineering and the sciences, see *Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers* (Council of Science Editors 2014, chap. 12); *ISO 80000-2: Quantities and Units—Part 2: Mathematical Signs and Symbols to Be Used in the Natural Sciences and Technology* (ISO 2009); or Scheinerman (2011).
- c) In the methods section, discuss the theoretical and experimental techniques that are used.
 - In an application paper, discuss the development of your simulation model (i.e., input-data collection as well as the design, implementation, verification, and validation of the model).
 - For guidance on writing a paper that involves substantial mathematical development, see Halmos (1970), Higham (1998, chap. 3); Knuth, Larrabee, and Roberts (1989, 1–6); or Krantz (2017, chap. 2).
 - For guidance on writing a paper that involves the theory or methodology of computing, see Knuth, Larrabee, and Roberts (1989, sec. 10–14) or Zobel (2014, chap. 10–11 and chap. 14).
- d) Plan the results section to achieve the most effective mix of text, tables, and figures in the presentation of your results. Tufte (2001) is a definitive reference on the design of tables and figures.
 - For a comprehensive discussion of constructing and using tables, see also Gastel and Day (2016, chap. 16); Matthews and Matthews (2014, chap. 7); *The Chicago Manual of Style* (University of Chicago Press 2017, sec. 3.47–3.88); or Zobel (2014, chap. 11).
 - For a comprehensive discussion of constructing and using figures, see also the *AIP Style Manual* (AIP 1990, chap. V); Gastel and Day (2016, chap. 17–18); Matthews

and Matthews (2014, chap. 8); *The Chicago Manual of Style* (University of Chicago Press 2017, sec. 3.3–3.46); or Zobel (2014, chap. 11).

- For guidelines on how to integrate figures and tables smoothly into the text, see Heard (2016, chap. 12).

3. Plan the discussion section.

- a) Explain how the theoretical and experimental results relate to the original problem. State why these results are important.
- b) Explicitly state the limitations of your study. Schimel (2012, chap. 18) discusses effective ways to handle this issue honestly and constructively.
- c) Summarize any unresolved issues that should be the subject of future work.
- d) State the final conclusions explicitly in plain language.
- e) In some fields, the main conclusions and recommendations for future work are given in a separate section following the discussion section (Alley 2018, 131–132). In this situation, the final section must not simply repeat the findings in the discussion section. See also item II.C.12 below.

II. Write the paper.

A. Select a concise title that will capture the reader’s attention by accurately and forcefully summarizing the paper’s contribution and thus stimulate interest in reading the abstract and introduction. For guidance on selecting a title, see Alley (2018, 110–114); Carter (1987, 84–91); Gastel and Day (2016, chap. 7); Higham (1998, sec. 6.3); or Matthews and Matthews (2014, 71–74).

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 Carter (1987, 91–93); Gastel and Day (2016, chap. 9); or NISO (2015).

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

1. ***Hit the ground running, and build your writing momentum steadily.*** Begin writing at a convenient point after the introduction, such as the section on experimental results or the summary of final conclusions and recommendations for future work; then keep to a daily quota or schedule for writing to ensure that you meet the deadline for submitting the paper. Often the abstract and introduction can be written more easily after you have completed an initial draft of key sections in the rest of the paper. For authors at all levels of experience, Heard (2016, chap. 5–6) gives helpful advice on how to make a strong start and then steadily increase the pace of writing.

2. In writing the introduction, keep in mind the following advice:

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 material to the paper, you may need to review and revise some of the material written so far, especially the abstract and the introduction. For more on the spiral plan of writing, see Halmos (1970, sec. 6) or Higham (1998, chap. 7).

- a) Like the abstract, the introduction should be intelligible to general readers in the field of simulation.
 - b) In later sections of a methodology paper, an advanced tutorial, or a domain-specific application, you may assume that the reader has an advanced background in the given subject.
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 (i.e., at the beginning of the sentence) the old information linking backward to the previous discussion.
 - b) Place in the stress position (i.e., 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 further explanation of the principles of scientific writing based on reader expectations, see Gopen and Swan (1990); Heard (2016, 168–173); Williams and Bizup (2015, 44–55); or Williams and Bizup (2017, 79–92).

4. Devote a separate paragraph to each new idea.
- a) Begin each paragraph with a sentence that summarizes the idea 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 frequent use of paragraphs having extreme length—i.e., one-sentence paragraphs and those exceeding 15 lines or 300 words; see Alley (2018, 130–131); Higham (1998, sec. 4.23); or van Leunen (1992, 133–134).
 - d) Place the important conclusions in the stress position at the end of the paragraph.
5. 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.
6. For application papers, emphasize the new insights into the problem that you gained from developing and using the simulation model. Give equal emphasis to lessons learned from your work that are relevant to other applications.
7. 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 must not be called “orthogonal” even if any two columns of that matrix are orthogonal vectors.
 - b) For standard usage of statistical terms, see Dodge (2003), Porkess (2005), or Upton and Cook (2014). For example, the probability density function of a continuous random variable must not be called a “probability mass function” or a “distribution function.”

- c) For standard usage of computer terms, see Black (n.d.), Butterfield and Ngondi (2016), Computer Hope (n.d.), or Howe (n.d.). For example, a recursive function must not be called an “iterative function”; and a recursive procedure must be carefully distinguished from an iterative procedure.
 - d) For standard usage of industrial and systems engineering terms, see IISE (n.d.). For example, the time that a workpiece spends in a manufacturing system may be called “cycle time” or “flow time” but not “throughput time.”
8. Avoid illogical or potentially offensive sexist language. See Miller and Swift (2001) for a commonsense approach to this issue.
 9. 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. In vendor tutorials, the authors must not make unfair or offensive comparisons of their products with competing products.
 10. For each table, compose a caption that briefly summarizes the content of the table. Comment explicitly in the text on the significance of the information in the table; do not force the reader to guess at your conclusions.
 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. When summarizing your final conclusions and recommendations for future work, keep in mind the following advice:

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. *Revise and rewrite until the accuracy and clarity of every sentence are unquestionable.*

1. For questions about the rules of English grammar and usage, see Berger (2014); Harper-Collins Publishers (n.d.); Fowler ([1926] 2015); Fowler, Aaron, and Greer (2019); Garner (2016); *Oxford English Dictionary* (1989); Strunk and White (2000); or *Webster’s Third New International Dictionary of the English Language, Unabridged* (1993).
2. If you use English as a second language, see Booth (1993); Fowler, Aaron, and Greer (2019); Huckin and Olsen (1991); or Yang (1995).
3. For guidelines on how to edit your own writing, see Cook (1985), Heard (2016, chap. 21), or Wilson (2002, sec. 5; 2017, pp. 25–27). ***Effective self-revision requires mentally simulating the reader’s reaction to your paper—i.e., reading the paper from the viewpoint of someone whose knowledge of your work is based entirely on the current content of the paper—and then revising the paper to eliminate the problems identified by that simulated reader.***
 - a) For the target audience identified in item I.A.3 above, reader simulation is relatively hard to perform because of the following:
 - substantial uncertainty or variation in the background knowledge of the individuals in the target audience; and

- the inherent difficulty of mentally substituting a reader's secondhand knowledge of the work in place of your firsthand knowledge of all aspects of the work.

See Heard (2016, pp. 196–200) for good advice on mentally simulating readers in the target audience.

- b) For the reviewers and editors of your paper, reader simulation is relatively easy, because those individuals are experts in the relevant area, and their reactions to reading your paper can be predicted with reasonable accuracy. See Wilson (2002, sec. 5.1; 2017, pp. 25–28) for a comprehensive checklist of specific questions that a reviewer or editor should answer when writing a report or making an accept/revise/reject decision on your paper; thus it is straightforward to simulate mentally (i.e., anticipate) the concerns of such a reader and then resolve those concerns as you write or revise your paper.

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

1. The author-date reference system 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 reference system.
2. In preparing the list of references, you should strive for accuracy, completeness, and consistency. ***Using the information provided in the list of references, the interested reader should be able to locate each source cited in the paper.***
3. For complete instructions on citing electronic sources, see sections 14.6–14.18 of *The Chicago Manual of Style*. For example, sections 14.7 and 14.8 contain basic information on uniform resource locators (URLs) and Digital Object Identifiers (DOIs), respectively. Many examples of citations for various types of electronic sources can also be found throughout chapter 15 of *The Chicago Manual of Style*.
4. The final electronic version of your paper—i.e., the portable document format (PDF) file generated from the Word or L^AT_EX file of your paper—may include hyperlinks to some of the sources cited in the paper that are accessible online.
 - a) When you view the PDF file on a computer screen, each live hyperlink is colored blue; and you can click such a hyperlink for immediate online access to the cited material. Clicking a live hyperlink will activate your web browser so that, if all goes well, the cited source of information will be displayed in the web browser. A live hyperlink may also be used to activate email software for sending a message to a selected email address; for example, see the hyperlink given in the first paragraph of section 1 of this document.
 - b) If a 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 that material, you must copy and paste the URL or DOI into the address bar of a web browser. For examples of hyperlinks that are not live by design, see Alexopoulos et al. (2019).
 - c) If you use hyperlinks in your paper, then you must ensure that the text displayed for each 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 hard-copy source; neither the editors nor the publisher of the proceedings can verify any of this information for you.

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

III. Cultivate a natural and effective writing style.

A. Consider the following memorable statement on style by Alfred North Whitehead.

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 conducting an investigation of the celebrated phenomena of chromatic refrangibility, a right-triangular dispersive prism was requisitioned. After darkening the experimentation facility and making a diminutive aperture in an otherwise opaque window covering in order to ensure that the optimum quantity of visible electromagnetic radiation (VER) expressed in lumen-hours would be admitted from a solar source, the prism was placed in the vicinity of the aperture for the purpose of refraction of the VER to the wall on the opposite side of the facility. 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 jargon-filled, impersonal language in 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." In the second sentence of version 2, notice the dangling participles, confusing sentence structure, and excessive length (67 words). Isaac Newton (1672, 3076) wrote version 1. Even though it was written over 345 years ago, Newton's prose is remarkable for its accuracy, clarity, and conciseness.

C. Strunk and White (2000, chap. V) 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.

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 obtain it in electronic or hard-copy form.

Finally, always keep in mind your overriding goal—to communicate your technical contributions accurately, clearly, and forcefully to your intended audience. Achieving that goal requires meticulous planning and intense concentration sustained over an extended period of time; 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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