Writing Technical Papers or Reports

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Five rules that help to improve technical writing are (1) Start at the end; (2) Be prepared to revise; (3) Cut down on long words; (4) Be brief; (5) Think of the reader.

KEY WORDS: Technical writing; Communication; Revision; Long words; Brevity; The reader.

What is our aim in writing a journal article or a technical report? Do we want it to impress by its length and convoluted style, or to be read, understood, and remembered?

Technical writing is plagued by the belief that it is judged by its length—the longer, the better. Yet we all have too much to read and printing budgets are often constrained. As a reaction, there are frequent calls to be brief and to write clearly. The National Science Foundation, for example, asks that proposals be limited to 15 single-spaced pages.

But how can brevity and clarity be achieved, especially with our complex technical subject-matter? Much advice about writing is good but very specific, like "Use active and not passive verbs." It does not have much impact. There are, however, five rules that can have a wider, more pervasive effect. Whenever I do not manage to apply them fully, I know I could have done better.

THE FIVE RULES

1. *Start at the End.* We usually write papers or reports in a historical way, finishing with our results and conclusions. But readers usually want to know our findings before learning how they were obtained. Technical reports and learned articles are not detective stories. We therefore should start at the end, giving our main results and conclusions first.

2. *Be Prepared to Revise.* Few people can write clearly without revision.

3. *Cut Down on Long Words.* Technical writing is often dense and heavy. It can be made more readable by using shorter sentences and fewer long words.

4. *Be Brief.* Brevity is best achieved by leaving things out. This works at all levels: sections, paragraphs, sentences, and words.

5. *Think of the Reader.* We must consider what our readers will do with our report or paper. What will they want to communicate to others?

I now discuss in more detail why these guidelines work and how they can be implemented.

RULE 1: START AT THE END

The structure of a paper or report—the order of its sections—is the key to its success. Readers should not have to start by turning to the last page first, nor should they as a rule have to skip and skim. As authors we know what our papers are about; hence we can set out the material in the order in which we expect it to be read.

Technical writing often does not do this. Instead, its structure reflects the order in which the work was done. A typical sequence of the main sections might be

1. Objectives
2. Background
3. Methods
4. Results
5. Conclusions.

That seems logical for us, since that is how we did it. But a better sequence for the reader is if we start with a brief introduction and then give the main results and conclusions in full:

1. Main Results and Conclusions
2. Detailed Findings
3. Methods
4. Background
5. Evaluative Discussion.

Not all papers or reports need follow this structure precisely—it is the spirit behind the rule that matters. The paper will need clear sign-posting whatever its structure.

Giving the main results and conclusions early may seem heretical to some, but it works for the reader. There are four main reasons:

a. The format works better for a mixed audience. (All readers can start at the beginning and then stop anywhere, knowing that they will have covered what matters most, and knowing what they are missing.)

b. Readers will have a mental framework (i.e. the main findings) to guide them if they *do* read on.

c. The conclusions will be more comprehensible. (When writing we will not assume that readers already know the technicalities in the body of the paper. We

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have all seen final conclusions which begin "R_+* (SDD) is an adequate robust estimator of P . . .")

d. The report can be made briefer.

With this format the different parts or sections of a report or paper will then function as follows, starting with the front matter:

Title, author, and abstract: These mainly help potential readers to screen out things which they do not want to read. (The abstract or summary should state results, not objectives—"We *successfully* investigated . . ."—but it will usually be too condensed to communicate fully.)

Introduction: This is the second screening stage. Readers need a few words on the aims and the background—little more than a clearing of the throat. One or two well-known references can help to set the scene, with just enough about methods to stop readers asking themselves "How was it done?" But no details yet.

Main results and conclusions: Now we give the main results. The maxim here is "Never hold back what matters." If there is anything we intended to lead up to dramatically later, we should say it now. The main results should be followed by our conclusions and recommendations, if any. Many readers can then stop.

Detailed findings: Secondary findings and detailed arguments will mean much more to readers if they already know the main results and conclusions. And having made our basic points, we in turn will feel freer to relegate much of the detail to appendices, a filing cabinet, or a data-bank. Why not say "Fuller information on so and so is available," and wait for the rush?

Methods: The introduction will have given readers only the briefest hint of methods. They can now be described more fully. Knowing our conclusions, readers can judge our methods better. Once again, much of the detail can be condensed, put into an appendix, or left out.

History and Background: Putting this section early serves neither the newcomer nor the more knowledgeable reader. The one does not want a long list of strange names and dates, and the other has already seen them before. Towards the end of the paper it is different: both kinds of reader will want to know how the new findings fit into the broader context ("Brown (1935) was *right* when he said . . . "). But we need no longer impress with our erudition since our results have already been judged in their own right. Reference to some earlier literature reviews may be enough.

Evaluative Discussion: Those readers who are still with us will now want to know what we would do differently if we could do the study again. What objectives did we not manage to cover? What might be done next? What longer-term implications are there?

We need not be afraid to summarize also what we have already said. It is very comfortable to read a paper or report where the author tells us what he is going to say, says it, and then brings it all together for us again. A final summary is also a good discipline for us as authors: Is this what we really meant to say?

RULE 2: BE PREPARED TO REVISE

Even professional writers redraft their pieces if they have time, so as amateurs we should not expect to get it right immediately. Revision can be a never-ending process: the question is how much work to do ourselves and how much to leave to our readers.

The first step is developing an outline, that is, listing and rearranging the main points or headings. Next comes the first draft. This may be easier to write in a historical order—as we did it—unless we literally know our material backwards. Most of us need to write out a full draft, however rough, before our ideas begin to jell.

Having committed our thoughts to paper, we now know better what we wanted to say. Unexpected connections, gaps, and discrepancies begin to appear. We can also put the main points in their right order and see much better what to leave out. This leads to a new outline and a new draft. The process may well need to be repeated, perhaps often.

Getting a Fresh View

A major problem in revising our own writing is that we are far too close to it. There are several ways of getting a fresh view:

- Leave the draft for a week or two, or longer. (If we cannot wait this long, we should try to start earlier next time, *at least with some rough notes or outline.*)
- Describe the draft or outline to someone else. We will find ourselves saying things like, "What I meant to say here was . . . " Write this down. It is what we meant to say, but didn't.
- Have someone read the draft who will not hesitate to write "Unclear" or "Too wordy" in the margin (and sometimes perhaps even "Good"). We often see almost instantly how unclear or long-winded we have been.
- If possible, ask the friendly critic also to go through the draft with us and tell us why he or she wrote "Unclear," and so on. He may say more than he wrote. Hard though it may be, we should never seek to defend ourselves. When the critic cannot understand something, it is always our fault. (Even editors' and reviewers' criticisms, however misguided usually, are only responses to what we wrote.)

RULE 3: CUT DOWN ON LONG WORDS

We are often told to use short words and write clearly. A helpful device here is the "fog-factor."

For this, we count the words of three or more syllables and the number of sentences on about half a page of writing. (I count the long words in my head and the

sentences on my fingers.) We then divide the number of long words by the number of sentences.[1]

A piece with a fog-factor of 2 or 3 remains easy to read. If the count goes up to 4 or 5, it becomes heavy going. Yet academic and technical writing often averages 6 to 8 long words per sentence, and sometimes more than 10. Which is why it is like it is. (Long words strain our short-term memory. They make it difficult to remember how a sentence started by the time we reach its end.)

Good novelists cope with basics like life and death on a fog-factor of less than 1. But in technical writing we are handicapped. We need long jargon words like statistics, regression, or correlation coefficient—they can be a useful shorthand if used often enough to be worth learning. (It helps to remind the reader once in a while what a jargon word means.) But an average of 2 or 3 long words per sentence still gives us plenty of scope.

The definition of the fog-factor is not watertight. Are there two syllables in "ratio" or three? What about names, numbers, and abbreviations? But the precise definition does not matter—we are not playing games. A low fog-factor does not guarantee good writing, but a factor of 4 or more provides a warning. It is tempting to make excuses ("My topic is very complex . . . "). Yet a high factor can always be reduced by cutting out long words, by replacing Latin derivatives by Anglo-Saxon ones (e.g. fundamental by deep), and by dividing long sentences. Appendix A gives an example.

Splitting a sentence in two will halve its fog-factor. Short sentences are in any case good in their own right. The end of a sentence tells the reader that he can stop and think. He may even want to read the sentence again. This is easier if the sentence is short. (A short paragraph similarly allows the reader to go back and reread without losing his place.)

Not all sentences should however be short. That would make for too abrupt a style. But a long sentence should be there for a reason, such as giving a qualification or illustration before the reader is allowed to stop and think.

RULE 4: BE BRIEF

Being brief is good for the reader but costly for the writer—it can take much effort. The best way is to leave things out altogether. Just because we did a lot of work we do not have to tell everyone all about it.

We can cut the detail if we give our main results early. Instead of leading our reader carefully through an argument or proof, we can start with our conclusion, for example that Product X should in future be packed in metal cans rather than in glass bottles. We then follow this with our three main reasons: (1) . . . , (2) . . . , and (3) . . . Q.E.D.

How thoroughly do we now need to discuss the other factors? Often a brief listing will do: "We also considered factors *a, b, c,* and *d,* but they did not greatly affect the conclusions." That indicates our thoroughness without parading all the work we have done. (Karl Pearson was once likened to the small boy who insists on showing you the *whole* of his stamp collection.) If we want a weighty report, we can use appendices.

Drastic pruning is also needed with paragraphs or sentences. A useful precept was noted by Dr. Johnson 200 years ago:

> Read over your composition, and wherever you meet with a passage which you think is particularly fine, strike it out.

The precept is easier to follow when a passage seems unclear and we are struggling to improve it. We can again just leave it out—it cannot be that important if it is still unclear. So "When in doubt, cut." This works wonders.

We also need to prune verbiage. For this we need help from critics ("Too wordy") and to develop self-criticism ("Is this word or phrase really necessary?"). An example is given in the Appendix.

RULE 5: THINK OF YOUR READER

Putting ourselves in our readers' shoes is difficult. Their problems differ from ours. To bridge the gap it helps to consider what they will do with our paper or report. They will probably want to remember our main results and the nature of our argument and its limitations, but not detailed proofs, derivations, or data. Details can therefore be given selectively, and later or in an appendix rather than sooner.

In the analysis of packing Product X in cans rather than bottles, we have taken account of costs, labor relations, transport, trade and consumer reactions, and so on—the lot. We now have four days to write the report. Our worries are: How should we structure the report? Can we get it done in time? Will our assumptions be accepted? Should we give a visual presentation with charts?

Our reader has different problems. He is Marketing Director and is launching a new product in the South. He has not been thinking about our report; anyway, the meeting in question has been postponed. He looks at the report a couple of weeks later when he has to prepare his own memo about the future of Product X: Should he mention our conclusions about cans versus bottles? But his main worries are: Can he get his memo done in time? Will his views be accepted? Should he make a visual presentation to the Board?

As writers we are worrying what to put in our report. Our readers wonder what they can get out of it. They often need to give a summary or extract to their boss, or colleagues, or students. It is good to try to draft this. It shows us how much of our report is only what we wanted to say and how much a reader might actually

[1]The fog-factor is a major simplification by my colleague T.P. Barwise of Gunning's fog index. See T.P. Barwise (1981), "Five Rules for Report Writing," *London Business School Journal*, 5(2), 32–34—reprinted in *Handbook for Managers*, Ed. M.E. Levene, Instalment 31 (Winter 1982), 4.6-301 to 4.6-306—and R. Gunning (1952), *The Technique of Clear Writing*, New York: McGraw-Hill.

need. (He or she will probably select one or two of our findings, add a reservation, and give a hint of our methods: "These conclusions are based on a painstaking analysis of the different alternatives, carried out by our Mr. Z.")

With technical writing most of our readers already know something of the background. In particular, the boss or client who asked us to write the report already knew the problem, and may by now also know the answer: "Where is that report where you prove that bottles are better than cans?" Remembering this should help us cut down on the things that our audience already knows. (Student papers differ here from other technical writing.)

We should also watch ourselves reading or skimming other people's reports, articles, or books. What do we get out of them? What strikes us as good or as bad (e.g. "Why doesn't he get on with it and say what it's all about?" or "Why is there no signposting?") It is much easier to criticize other people's writing than our own, and it is more fun. But we need to learn from it for when we do our own writing.

DISCUSSION

Difficulties in writing a paper or technical report center on deciding what to say and how to say it. The five guidelines discussed here aim to help us with the "how to say it":

1. Give the main results and conclusions early.
2. Be prepared to revise.
3. Cut down on long words.
4. Be brief.
5. Think of the reader.

More basic still is the need to clarify *what* to say. This is less easy to generalize about. But the five guidelines also help in organizing our thoughts. For example,

- Starting with our main findings in full forces us to commit ourselves early on: "This is what I am saying."
- Revision, the reactions of friendly critics, and thinking of our readers all help us to focus on what we are trying to say.
- Too many long words and excess verbiage usually reflect muddled thinking. Sentences which start with "Clearly, ... " are never clear. (Otherwise why say "Clearly ... "?) Usually they are not even true.

The rules or guidelines discussed in this paper do not make the job of writing easier, but they should make our writing easier to read.

APPENDIX: CUTTING LONG WORDS AND VERBIAGE

Reducing the number of long words (Rule 3) and getting rid of excess verbiage (Rule 4) require different skills. In neither case is there a single right answer. In the end we want to produce writing that is better on both counts. To illustrate, a recent report on "Broadcasting and Youth" opened:

> In the UK and throughout the western world a rapidly growing proportion of young people appears to be faced with the almost certain prospect of periods of prolonged unemployment, brought about by fundamental changes in the structure of industry and commerce. However, many young people currently in employment find that a lack of initial basic educational skills, together with the lack of access to training facilities at work, means that their ability to adapt to these changes is also very restricted.

There is nothing way-out about this, but it is rather heavy and dull. It has 15 words of three or more syllables in two sentences—a fog-factor of $7\frac{1}{2}$. And the report goes on like that for 100 pages.

Replacing some of the longer words and cutting the first sentence in two reduces the fog-factor to 1:

> In the UK and throughout the western world more and more young people appear to be faced with the almost certain prospect of being out of work for long periods. This has been brought about by deep changes in the structure of industry and commerce. Even young people who have a job find they cannot adapt easily to these changes since they lack basic skills and have no access to training at work.

This is easier to read. Seven times as many three-syllable words per sentence now seems horrendous. But it is still wordy. We can prune the verbiage without major loss:

> More and more young people are likely to be out of work for long periods, owing to deep changes in industry and commerce. Even those who have work may find they lack the skills or training facilities to adapt to these changes.

That is 40 words compared with 70 or 80. The pedantic qualifications ("In the UK and throughout the western world.... ", or "a rapidly growing *proportion*") are largely irrelevant, especially in an opening paragraph. If they matter, we should discuss them properly, later. But if in doubt, leave out.

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