1 Introduction

The purpose of this document is to discuss how I approach the writing process with the intent of passing on some methods and ideas that work for me.

For many, the preparation and writing of technical documents is a difficult task. This is especially true for writers who do not speak English as their first language. Often writers begin their task with no planning whatsoever and without a clear vision of the purpose of the document that they intend to create. That is, they do not know how or where to begin and how to follow through to the finished product. There is a process to technical writing that is clear and straightforward. This process in nearly formulaic such that it is implementable for virtually any document that you need to create. Note that I did not write that is is “easy” to implement because writing is work! Once, the basics of technical composition are mastered, there is significant room for individual style to be expressed.

The discussion falls into three parts. First, I present the technical writing process in a stepwise fashion so that it is, hopefully, straightforward to implement. Second, the information presented in the various sections of a report or article is summarized. Third, some elements of style are presented.

2 The Writing Process

There are five steps to the technical writing process that I employ:

1. preparation
2. planning
3. outlining
4. drafting
5. revision
Often these various steps overlap and are completed simultaneously rather than in a linear fashion. When I encounter difficulty in writing, I follow each step explicitly. With other projects, the process comes naturally. Each step is now discussed in detail.

2.1 Preparation

The preparation stage comes almost entirely before beginning to write. How you conduct yourself during research or in the solution of a course project impacts your ability to write. It is now cliche, but you need to work smarter and not harder at this point.

Preparation begins by understanding the information available in the literature and the accumulated knowledge of your colleagues. First, have you covered the background material? For a research project, have you conducted an adequate literature review? Students tend to either locate and read too many papers in too much detail or too few papers in insufficient detail. When you dig up some references or are handed a stack of papers to read, it is wise to scan a set of the papers first. I scan the abstract, conclusions, and reference list. The first two are helpful for gaining a basic understanding of what was accomplished in each paper. The third tells you the papers that others found helpful. Do you see, the same paper(s) appearing over and over in the reference lists? If yes, there is a chance that these papers are foundational or seminal works that you should consult in detail.

Colleagues are a great source of preparatory help. Are there others, working, or who have worked, on a topic similar to you? If so, you should ask them what are the key references that they have found and what they learned from them. Then you invest time in reading and understanding the key papers. Here you try to understand what they did, how they did it, and what the important contribution was. The remaining papers that you did not identify as key contributions are then scanned more thoroughly than on your first pass. It is generally a good idea to catalog the key idea(s) of each.

As you conduct your work, you should do so methodically and record your work in a manner that is easy to remember what you did and what you thought your results were teaching you. If you are conducting experiments this means writing down in your notes/labbook what you did as well as changing experimental variables in a logical fashion. How can you check if it is logical? Ask someone to review your procedure! Similarly for modeling work, record your derivations as neatly as possible. If you make an assumption, write it down for future reference. How do you know if your assumptions are reasonable? Again, ask someone. If you fill up a ream of paper with work and you do not think the work to be immediately helpful, number the pages, write yourself a one page summary of what you were trying to do, and file away your notes. When you prepare plots to check results as you work, label axes, columns of data, etc. It does not have to be pretty, but having preliminary plots and
the ability to plot data quickly in a variety of different ways helps you at the outlining stage in deciding how to present your work.

In short, you should work methodically even when you are uncertain as to what your final results and conclusions will be. Working methodically, however, does not mean that you should spend excessive amounts of time organizing and collating your work. This is where the principle of “optimum sloppiness” comes into play. You need to spend just enough time and effort at organization and documentation to aid yourself later. Documenting your work as you go, storing your data in a logical fashion, and archiving any code that you are creating on a regular interval help tremendously.

2.2 Planning

You arrive at the planning stage when you think that your work is ready to be written up, or when you have run out of time and your report/paper/thesis is due soon. During planning, you take the work you did during preparation and try to establish the story that you will tell during the drafting and revision stages. You also consider the exhibits, such as figures, equations, and tables, that will be presented to tell your story.

The first two steps of planning are to Identify your audience and the type of document that you are producing. A two page summary of your work to appear on a publicly available website or a short memorandum to your boss about your progress over the last month are much different documents from a full blown research paper. Hence, they require different planning. In fact, the shorter document may require substantially more planning than the longer document. With the shorter document, you must choose your message carefully and prepare minimum exhibits (figures, tables, equations) to communicate your results and interpretation. You may realize that you need to find an entirely different way to explain your results to communicate to a general audience. On the other hand, your boss may need minimal background information and be interested solely in results.

One common method of planning that I employ is to write (or print) out the set of figures and tables that I think might be used in the paper. At this stage, I work for information density. That is, conveying the most data/information/results with the minimum number of exhibits. You may find that you cannot produce every figure with the work that you have done already during preparation, or you may find that a key result is missing. If this is the case, then you either change the story that you want to tell or generate the key missing results.

If you find that you need 40 figures and 20 tables to tell your story and you are writing a paper for a journal publication or for an SPE meeting, then this is a signal of trouble to come. You need to consider if multiple figures can be condensed onto one figure by replotting results or presenting results using nondimensional parameters. If
you cannot reduce the number of figures, then you should plan a different story with fewer figures.

Another common method of planning is to meet with someone familiar with your work, such as your research advisor(!) or a colleague, and review with them the plan that you have for your paper. Does the story make sense to them? Do they find that you have a logical progression of ideas?

In summary, during planning you are preparing to write the outline. The chief function of planning is to check if you have a compelling story and the supporting exhibits to prove the story. If you have neither, you need to return to preparation. The result of planning is the central idea that you want to communicate to your readers and an idea of the exhibits that you will use while writing.

2.3 Outlining

The outlining process is where you pull together the preparation and planning stages to decide the best way to organize and present your work. This is the stage where you begin to craft your paper/thesis/report in earnest. You need to decide a method of presentation and this is where your work in the planning stage comes to play. There are some obvious choices for organization such as chronological, sequential, increasing level of importance, etc. For a first, year M.S. report, the chronological approach may be best. In this sense, you might say, I tried approach A, followed by approach B, and in the future I will try approach C. For a review article, you might approach the subject in order of increasing (or decreasing importance). For a thesis, your intent is to teach and convince the reader that you have followed a logical course of research and contributed to your field. You will probably follow a logical presentation of prior work, your new results, and a discussion of them.

The object of outlining is to plan how you will write your first draft. This is where you take the large, complicated subject about which are are going to write and reduce it to a series of sections that are manageable both to write and for your audience to understand.

The method that I like to use for outlining is to create the section and subsection titles in a document. This becomes the Oth rough draft of your article. I even apply the styles for the headings at this stage. Within each section and subsection, I create a list of items that I want to talk about. For instance, in the Introduction, I might say “Review the 8 papers that are foundational, make sure to comment on our recent work, write a clear statement of the contribution of this article.” If I find that I am having trouble with the outline of a section, I make general notes as to what I should be doing. For instance, in a section on model development I might write, “(i) don’t forget all of the assumptions, (ii) present the equations and describe the logical transition between the equations, (iii) discuss the boundary equations and how they satisfy physical criteria, (iv) discuss, briefly, the method of solution.”
After you have prepared a first attempt at an outline, you then review the outline. Does it meet your expectations from the plan? Does it present the logical development of a single idea? Are there discussion items that you should add to the various sections? If you rearranged the parts of the outline, do you think that the article is easier to write? Would the article be easier to write and be easier to present to your audience if you changed the method of presentation? This is your stage to play with the paper and explore various opportunities for presentation. Spending time to craft an outline that you understand and is logical saves much writing time. You may even decide at this stage to return to preparation because your knowledge or your results is incomplete.

Your goal at the end of the outlining process is to exit with a clear vision of how the paper is organized and what you plan to write for each section. This is your goal, but it may not meet reality. A well crafted outline, however, it is the foundation on which you build your writing. You simply fill in the blanks within the outline.

2.4 Drafting

When you reach the drafting stage you have decided on your audience, the story that you want to tell, and you have drafts of the exhibits that you will present. The best advice that I can give for crafting a first draft is simply to write and not let shortcomings in preparation, planning, and outlining slow you down. Skip the Abstract, for you write that last. Do not worry if you have mispellings or grammatical errors. If a certain section presents trouble to you, move past it. You can return to it after more of the paper is written. The Introduction is always difficult to write. If you encounter trouble, move on by skipping the section or subsection.

Writing does not have to be linear. If there is something that you find that you need to add but you are not prepared to write, make a placeholder for yourself. For example, in the Discussion you might write: "You need to discuss how your results are both similar and different from X. Go back and review the work of X."

You may find that it is difficult or impossible to reduce your outline to text. What you may want to write is very much different from your outline. Do not despair, return to the outline and revise. You may even find that the story you are writing is different in comparison to what you planned. This may be OK. You need to return to planning and decide if you need to just keep writing or if you need to stop and get back onto your previous plan.

Finally, remember that drafting is the process of converting your outline to text. Revision is the process of making it readable. Hence, the advice to simply write so that your ideas move from your brain and onto the hard drive of a computer. Write without fear at this stage.
2.5 Revision

In my opinion, revision is the most difficult stage. Frequently, enough revision does not occur and whatever you are writing does not reach its full potential. It is important to allow sufficient time so that sufficient revisions occur.

You need to adopt a frame of mind during revision that is quite different from drafting. First, try to read and view the manuscript from a reader’s point of view. At this stage, I find it helpful to print the document and read it on paper. The ideas and words on paper allow you a new perspective. I adopt a process that can best be described by analogy to sanding a block of wood that is quite rough.

- First, you get a coarse piece of sandpaper and knock off the very rough splinters. In your paper, you look for large logical inconsistencies or missing information. Frequently, these include omission of important details such as description of apparatus, boundary, and initial conditions, and so on. Often, the discussion of results that you planned was not realized and you have an illogical or incoherent unraveling of your results.

- Next, you get a less coarse piece of paper and begin to smooth the surface. In the revision process, you return to the various sections and make sure that they express the points needed and you look for readability and improvements to the structure of paragraphs and sentences.

- Now, the wood is getting quite smooth and the surface needs careful sanding in only a few places with a very fine piece of sandpaper. In revision, you are now looking for items such as the transition between paragraphs and sections. Have you included all the necessary references? These include the key references that you identified and the other relevant papers.

In short, revisions move progressively from major missing items and deficiencies to details. At some point in this process, it is wise to ask someone else to read your work and give you their impression. They can tell you if the manuscript flows logically and if you have forgotten anything. If they can tell you the main point of the manuscript in their own words, then you have succeeded.

3 Sections of a Report

Next, I discuss the content of various sections of a report or thesis. The logical flow is similar for papers also, although you might call them by slightly different titles. Jon Claerbout’s website has a good description of the Abstract and Introduction sections. The actual titles of your sections will differ from those listed next. Moreover, you may have subsections within each of the sections.
3.1 Abstract

The abstract is a general summary of your work. It is the hook that you use to convince the reader to invest the effort needed to read your work. It discusses why the work was needed, how the work was done, and summarizes the results. Importantly, it is also tells the reader, why the work done was significant. You write the abstract last even though it comes first!

3.2 Introduction

This section is often the most difficult to write and you might spend a lot of time here with little accomplished. Again, here, you might refer to Claerbout’s excellent description of what an introduction is and how it is written.

Essentially, an introduction has four components. First, you tell the reader that an important problem exists. Second, you review the existing literature. During preparation, you identified a number of critical or important papers. Here you pick roughly 10 of those papers and discuss what they achieved. Third, you write the claim. In the claim, you establish that the work undertaken by you was worthwhile and that what you are writing is a contribution to the literature. Finally, you give the reader a sense of what lies ahead in the paper, what approach you use, and, perhaps, a sense of the results achieved.

3.3 Literature Survey

In a thesis or a report you generally need a more thorough literature review than that given in the Introduction. I usually prefer a separate section for the literature review to allow the Introduction to follow the formula above. The section title may be topical rather than “Literature Survey”. For instance, if your work is related to foam bubbles in porous media, your literature survey may be titled “Foam Transport in Porous Media”, or something similar. Subsections might be labeled “Pore Scale,” “Core Scale,” and “Field Scale.” Sometimes the literature review may be a subsection in the Introduction or a stand-alone section.

The literature should be evaluated so that the reader knows what has been done on this problem. It is not simply a factual summary resembling “Parmagiano-Regianno (2002) concluded that the earth was round. On the other hand, Columbus believed that the earth was shaped like a pear” Thus, it should be a critical review and discuss the shortcomings and limitations of previous work. You need to find and discuss such shortcomings. Otherwise, how could the problem that you are working on be of any interest to the reader? This does not mean that you portray the literature as worthless, but that it does not completely or properly solve the important problem that you posed in the introduction.
3.4 Procedure

The procedure section discusses how you went about solving your problem. The nature of this section, hence, depends on the nature of the problem solved. The title will be modified to reflect the nature of your problem too.

If your work is experimental, you discuss the experimental equipment in detail including any information that a future reader needs to know in order for them to repeat your work. You also discuss the experimental procedure. If this is a section to be included in your MS or PhD thesis, then you include a complete list of your sources of equipment and supplies. This is vital information for future researchers to replicate or modify your procedures.

On the other hand, if your work is mathematically oriented, you discuss the equations developed and how you went about solving them. This section should lay out the assumptions, some logical development of the final equations, as well as the initial and boundary conditions. The best mathematical sections lay out the equations and ensuing discussion in such a way that the physics are made transparent by the equations.

3.5 Results

As you know, this is the section where you present the fruits of your experiments or calculations. Also, this is where outlining before you write is important. A frequent failing of results sections is that the results are laid out in an illogical order. Frequently, students believe that work should be presented chronologically and they also believe that the work that required the most time to complete should be presented at the greatest length. But, you spent time in the planning and outlining stages identifying a logical flow for your results and you will not suffer from these problems.

3.6 Discussion

The discussion shows how your results answer the questions posed in the Introduction. It should outline the range of applicability of your results, the limitations (yes, there are always some), and the remaining uncertainties. Your work should be discussed and put into a larger context.

Avoid overly speculative discussions. Many researchers, in essence, extrapolate from one result to infinity. This is likely prone to give a poor discussion.

3.7 Conclusions

After the Abstract, Conclusions is the second most important section of the paper. Recall that when I scan your paper, I will read the Abstract and the Conclusions first. It is important to emphasize the results and their significance. So, in general, it
is a focused summary of the Results section. No new information or claims are made in the Conclusions.

Try to be quantitative in the conclusions. For example, if your results show recovery improvements of 14%, write this into the conclusions.

3.8 Additional Sections

As appropriate, you will have additional sections such as Acknowledgments, Nomenclature, References, and/or Appendices.

4 Style

Elements of style set your writing apart. Style pertains to how you write and how you present your work. Various elements are discussed next. A great reference with easily implementable tips for improving your writing style is Strunk and White (1979).

4.1 References

SUPRI-A reports use author-date referencing and full citations are collected in a section at the end of the paper. The advantage of author-date formatting is that it summarizes the reference so that the reader does not have to flip back to the reference list. Also, there is no need to renumber references when you add a new reference to the text. Examples of how you prepare the reference list are given in references below. Papers for the SPE have an entirely different format that should be followed explicitly. What is important to remember is that the style of the reference list changes slightly as references changes from author-date to numbered. Make sure that all of your references are in the same and the correct format. Finally, make sure that all references in the text appear in the references section, and vice versa.

4.2 Writing

Some elements of style and form are discussed next in no particular order.

1. Avoid words such as can, will, could, should, and so on. These are not definite forms of writing. Instead of

   It can be shown that our derivation is general by application of...

   write

   Our derivation is general. Application of the super-duper theorem to Eq. (191) demonstrates this statement.
2. Write so that the subject and the verb are both close to each other and near the beginning of the sentence. For instance, you write, “Figure 1 teaches ...” or “Dykstra and Parsons (1950) developed a mathematical framework...” If it is difficult to begin a sentence directly, begin with a parenthetical statement. See the previous sentence for an example.

3. Generally, try to write using short sentences. Also vary the sentence length so that a mixture of long and short sentences appear. Compound sentence constructions work well when longer sentences are needed. A compound sentence is two short sentences separated by an “and”.

4. Only use semicolons, ;, and colons, :, if you are sure that you are using them correctly. Additionally, avoid over usage of both of these forms of punctuation.

- A colon precedes a list or a particular item. A colon does not appear after a verb and before a list. For example a correct construction:
  
  There were four “Three Stooges”: Larry, Curly, Shemp, and Moe.
  
  A construction that is both grammatically and factually incorrect follows:
  
  The three stooges were: Larry, Curly, and Moe.

- A semicolon is generally used between two complete phrases (i.e., sentences); these sentences may be long and have a complicated structure. The preceding sentence represents correct usage. The semicolon is used when the ideas in each sentence are closely linked.

- Exclamations are also used sparingly so as to call attention to truly remarkable statements.

- An infinitive is the word “to” followed by a verb. You should not split infinitives by inserting an adverb between to and the verb. An adverb generally ends with an “ly”. For example, a correct construction:
  
  I need to run quickly to the store.
  
  An incorrect construction:
  
  I need to quickly run to the store.

- Go on a which hunt. The word which is almost impossible to use correctly (note the infinitive form) in technical writing. Edit your writing to eliminate whiches. You can generally do this by substituting that for which.

- Engineers tend to over utilize the word “utilize”. Use utilize sparingly and substitute “use” for “utilize”.

- Use both a dictionary and a thesaurus. The first is to check the meaning of words as you use them. The second is to find different words with similar meaning to avoid the overuse of particular words.
5 Conclusion

Practice does not make perfect. Rather, it makes permanent. Allow yourself sufficient time to go through the technical writing steps and allow sufficient time for revision to refine your writing. Strive for logical, clear writing, with easy-to-read sentences in all of your composition. Finally, writing about your work is often a creative and enriching aspect of research and coursework.

References


