

Improving Coherence in Technical Writing

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Abstract

The technical documents of many inexperienced student writers do not effectively communicate, even after the spelling and grammar aspects are addressed well. This results, because the student is not clear in his/her mind about the aspects that need to be communicated, although (s)he may be knowledgeable in the area. Also, the methods of effective communication are not well defined, and hence, first-time writers find it difficult to understand them. This article addresses coherence, which can significantly improve the communication, but is one of the elusive aspects for novice writers. This article aims to provide a structured approach that faculty members can use to improve the technical writing skills of students.

Introduction

It is well recognized that effective technical communication is an important skill that graduate/undergraduate students in engineering disciplines need to develop, and several good suggestions have been made [1, 2, 3, 4, 5, 6] to improve the same. Although good communication critically involves good skills in writing, speaking, reading, and listening aspects (www.writing-reading.com accessed on 3rd February 2003), usually, we concentrate on developing speaking (presentation),

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and writing skills in students. Between the two, usually, it more difficult to develop good writing skills. This is probably because good writing requires higher clarity and rigor in the thought process. Further, there is a general notion that one learns to write well as one learns to ride a bicycle, to play a musical instrument [7], or to swim, i.e., in an experiential manner.

When graduate students write their first manuscripts, the spelling and grammatical aspects are addressed first, either by a person comfortable with the language, or by a word-processor. However, a grammatically correct document may not always read well. When such a situation arises, many advisers know that the manuscript is not written well, but cannot clearly explain the reasons. They tend to talk about ‘clarity’ and ‘style’ (as distinct from that described in the Chicago, or the American Chemical Society, style manuals), and students get further confused. Ultimately, the advisers say, ‘it is all in there; you just need to communicate it better’, and ask the graduate students to re-write paper drafts, without further directions. Typically, students re-write their first manuscript many times, and the writing improves intuitively. During this process, reading well written scientific literature [8] is helpful. Finally, when the adviser accepts the manuscript, the students know that the final draft is better written, but are usually not aware of the reasons for the improvement in their communication. Since the same students later become professors/advisers, and University teaching is probably the only skilled profession for which there is no formal training (Felder, www.ncsu.edu/felder-public/RMF.html accessed on 3rd February 2003), the cycle continues.

This article presents a reasonably structured approach that faculty members can use to improve the writing skills of students. Alternatively, it provides a direction for the not-so-experienced writers of scientific material to improve their writing skills, consciously.

Coherence

Good communication, in written or oral formats, results from a good knowledge in the area, a clear awareness of the aspects that need to be communicated (and the aspects that need to be left out), clear thinking, and good organization, assuming that the language (grammar, spelling, and pronunciation) aspects are addressed well. For the most appropriate organization, one needs an awareness of how the reader/listener will perceive the information. In other words, one needs a good ability to ‘tell

a story', or, an ability to present the *relevant* material coherently. In fact, many advisers ask their students, 'What is your story?', when they discuss their research work. The above requirements become more critical in written communication because, the communicator is not present when the receiver reads the document. If present, as is possible during an oral presentation, the communicator can draw on non-verbal communication cues to bolster up the material that may be sub-standard from a communication viewpoint.

The published fairy tale is, arguably, the best example of coherent presentation. A child listens to a fairy tale being read by the parent, and understands the story, even while falling asleep. Therefore, if the students are able to understand the coherence aspects inherent in a fairy tale, they would be able to write (or present) coherently. This idea led to an initial exercise for the students taking the M.Tech. (graduate level) communication skills course at the Indian Institute of Technology (IIT) Bombay; they were required to narrate a fairy tale in front of their class. Not surprisingly, many students could not coherently narrate even a simple fairy tale such as Cinderella, the first time. An example was, 'Cinderella is that girl who wore a shoe. The Prince found her with the shoe. She went to the Ball in a chariot made from a pumpkin. There was a fairy that helped her. While running away from the Ball she lost one of her shoes. Cinderella had a wicked step-mother and two step-sisters...'; the chronological organization of information that is a crucial requirement for the successful delivery of a fairy tale was completely absent. Faculty members can compare the typical first draft of a manuscript written by a student with the above presentation of Cinderella; the similarity in presentation of mere facts, in the order of recall, without bothering about the relationships between them, could be striking.

However, there is an important distinction between the fairy tale narrative and the scientific narrative, i.e. the concept of external and internal times [9, 10]. External time refers to the time taken for the actual presentation of say, the fairy tale, whereas, internal time refers to the duration of the sequence of events that constitutes the tale. For example, if a person narrates the Cinderella story in fifteen minutes, the external time is fifteen minutes, but the internal time, is the few years over which the Cinderella story is set. While external time is relevant for both the fairy tale narrative and the scientific narrative, the internal time is normally absent in the scientific narrative, except, perhaps in the background section. Instead of the chrono-logic of internal time, a logical sequence

of scientific information (facts, graphs, tables, derived information, discussion, etc.,) is present. Normally, students develop the ability to present in a logical sequence, experientially.

Tools for Coherence

Students can be encouraged to develop the logical sequence of presentation, in a structured fashion, as described in a later section. Now, we will consider tools that can be used to improve the coherence (see Kies, papyr.com/hypertextbooks/engl_126/book126.htm accessed on 3rd February 2003), and hence the communication of the material after it is logically sequenced. To appreciate the use of tools, let us first see a well written passage by Bird [11], which has been slightly adapted here:

‘In educational circles today we hear a great deal about teaching and research. However, we hear very little about the activity of book-writing, which ought to be included as a third principal activity of a university teacher since it is concerned directly with the production, evaluation, organization, and dissemination of new knowledge. Therefore, I thought it might be useful to use this lecture to focus attention on the “rites, rewards, and responsibilities” of book authorship. Since I have had the pleasure and good fortune to co-author several books perhaps I can offer some appropriate words of encouragement to aspiring writers and even a few helpful suggestions regarding the art of writing. Maybe I can help others avoid some of the mistakes I’ve made. From time to time I will cite specific personal experiences in order to avoid discussing the problems of authorship in the abstract.

...

WHAT KIND OF BOOKS DO CHEMICAL ENGINEERS NEED

A library of professional volumes includes various classes of books: (i) *edited volumes* to present very recent developments by teams of experts; (ii) *research monographs* to catalog and evaluate the research published in the preceding 5-10 years; (iii) *treatises* to give authoritative, encyclopedic coverage to one particular topic; (iv) *textbooks* to set forth the basic ideas in the field in a form suitable for students; (v) *handbooks* to

summarize standard results of widespread use; and (vi) *design manuals* to provide up-to-date procedures for practicing engineers. Each of these categories has a different audience, and each requires special organizational talents. Generally speaking there is a flow of information from (i) toward (vi) in the above listing – that is, from innovative, exploratory, and (sometimes) impractical ideas of the researcher all the way to the time-tested and reliable tools of the practitioner. Along the way many ideas and methods are inevitably discarded, and only the most useful material survives to the arena of industrial practice. But without this constant exploration of new ideas and subsequent filtration, a profession can stagnate and atrophy.’

Repetition is an important tool for improving coherence. In the above example, Bird repeats the word ‘book(s)’ in a few places to build coherence.

If repetition becomes boring, **Synonymy** can be used; e.g., Bird uses the word ‘volumes’ to avoid a tiresome repetition of the word ‘books’ in the first sentence of the last paragraph presented. Similarly, **Antonymy**, using the opposite, can improve coherence; e.g., see the use of ‘impractical ideas’ and ‘reliable tools’ in the same sentence in the last paragraph of Bird’s passage (Bp).

The **Pronoun** is commonly used to improve coherence between sentences; e.g. the pronoun ‘it’ is used to refer to ‘book-writing’ in the first paragraph of Bp. Also, **Parallelism**, which refers to the use of the same sentence structure in subsequent sentences, improves coherence.

A tool that is commonly used by engineers is **Enumeration**, which refers to the use of specific markers of sequence to achieve the connection between the thoughts presented. A good example of enumeration appears in the second paragraph of Bp, in which Bird uses enumeration to link the various classes of books.

A tool that students easily learn is **Transition**. Transitions are conjunctions or conjunctive adverbs, which link sentences with specific logical relationships. They can be subcategorized according to their meaning (Kies, papyr.com/hypertextbooks/engl_126/book126.htm accessed on 3rd February 2003) as follows:

Identity. Indicates sameness: that is, in other words.

Opposition. Indicates a contrast: but, yet, however, nevertheless, still, though, although, whereas, in contrast, rather.

Addition. Indicates continuation: and, too, also, furthermore, moreover, in addition, besides, in the same way, again, another, similarly, a similar, the same.

Cause and effect: therefore, so, consequently, as a consequence, thus, as a result, hence, it follows that, because, since, for.

Indefinites. Indicates a logical connection of an unspecified type: in fact, indeed, now.

Concession. Indicates a willingness to consider the other side: admittedly, I admit, true, I grant, of course, naturally, some believe, some people believe, it has been claimed that, once it was believed, there are those who would say.

Exemplification. Indicates a shift from a more general or abstract idea to a more specific or concrete idea: for example, for instance, after all, an illustration of, even, indeed, in fact, it is true, of course, specifically, to be specific, that is, to illustrate, truly.

It is easy to see the use of transitions in Bp.

Thus, coherence tools can be used to improve scientific writing. It is unlikely that Bird was consciously aware of the coherence tools that he had employed while writing. However, as explained in a later section, the faculty member can encourage the novice writer to consciously use the tools, for writing better, until they become a sub-conscious part of the writing process.

A Structured Approach for Better Coherence in Writing

The coherence tools can only help improve a piece that was reasonably well written, initially. The following structured approach is one of the ways, by which well written drafts can be achieved. It is neither a panacea nor the only way, since there are as innumerable factors that contribute to good writing as to swimming. Also, many factors that contribute to good writing are related to the writer's personality.

The Preliminaries

1. The student needs to have the requisite knowledge/information in the area, before beginning to write. This is an absolute pre-requisite.
2. If a manuscript for journal publication, a thesis, or a report is to be written, a substantial number of the discussion aspects (say, 50%) must be clear to the student before the writing begins. Therefore, the student needs to be encouraged to analyze scientific material well, and note down the salient discussion points, with clarity, before writing. Many first manuscript drafts are poor in the discussion of data/simulations.
3. The student needs to be relaxed; (s)he can be encouraged to drink a glass of water; to take a few deep breaths, taking care to exhale more slowly than during inhalation.

Then the student needs to take a few blank sheets, a pencil and an eraser, or, a word-processor, and sit at a place where (s)he will not be disturbed.

The Questions

Now, the student should ask himself/herself the following *italicized* questions, and follow the suggestions given. To illustrate, I will present an example of my own thought process while writing a paper, a few years ago.

1. What is the main idea that I need to communicate?

For example, we had just discovered that induced free radicals could improve the productivity of cells in bioreactors, and we were very excited about the same. Therefore, the main idea that we needed to communicate was, ‘induced free radicals can be used as a novel means to improve bioreactor productivity’. Considerable thought may be required for first-time writers to realize the main idea that needs to be communicated. However, that is the place to start.

2. How do I communicate the main idea?

This is fairly simple for us engineers/scientists, because we are normally bound by the required format of the journal, the University, or the funding agency. Typically, we are required to communicate the main idea in various sections such as Introduction, Materials and Methods, Mathematical Model,

Results and Discussion, Conclusions, Nomenclature, References, Appendices, etc.,. Also, we rarely use anything except a linear presentation of information, which makes this aspect very simple.

3. Take one section at a time and ask the question: what do I want to communicate in this section?

Jotting Down

Suggestion: Write down the points as they occur to you.

For example, what do I want to communicate in the Introduction of the manuscript on induced free radicals? We were excited about the **novelty** of the strategy and therefore, I needed to communicate the novelty. I also wanted to communicate the various **contributions** that we have made in this work. In addition, I liked to tell the readers about what **motivated** us to do this work. Further, the typical reader of this journal is unlikely to know much about free radicals, and therefore, I needed to give **the relevant background on free radicals**. Also, to provide the necessary focus, I needed to present the **overall aim and objectives of the work**.

If the information is given in the above order, the reader, who will most probably not be familiar with the work, will find it difficult to understand. However, if the same information is presented in a logical sequence in the reader's viewpoint, his/her understanding, and hence the readability, would significantly improve.

Ordering Information

Suggestion: Put yourself in the reader's position. Now, order the aspects written in bold in the above section, logically. A possible list:

1. Relevant background on free radicals.
2. Motivation for the work.
3. Novelty of the strategy.
4. Overall aim and objectives of the work along with contributions.

Jotting Down - Paragraph Level

Now, let me take the first two aspects in the list to detail further. First, the relevant background on free radicals. From my reading of the literature, and my own experience with the work, I wanted to communicate (wrote them down as the thoughts arose):

(i) Free radicals can be expected to improve bioreactor productivity. (ii) Free radicals mediate cell processes such as cancer, apoptosis, etc.,. (iii) Free radicals are suspected to be the mediators of the effects of temperature, osmolarity, and nutrient levels (important bioreactor variables), on cells.

Logical Ordering - Paragraph Level

If I had written the above in the same order, an intelligent lay-person, the common reader, would have found it difficult to understand. Therefore, I needed to put myself in the reader's position, and order them in such a way that the common reader would appreciate. For example, a suitable possibility was:

1. Free radicals are known to mediate a number of cell processes including apoptosis and cancer (cite references).
2. free radicals are suspected to be the mediators of the effects of temperature, osmolarity, and nutrient levels, on cells (cite references) that are also important bioreactor environment variables.
3. Free radicals can be expected to play a significant role in determining bioreactor productivity.

Note that in the process, I had also improved the accuracy of the information.

Linking Sentences - Paragraph level

Suggestion: Next, link the sentences and improve coherence through the various linking tools mentioned earlier.

Free radicals are known to mediate a number of significant cell processes, including apoptosis, and cancer (Feig and Loeb, 1994; Feig et al., 1994; Okuno et al., 1998; Reid

and Loeb, 1993). **Further**, free radicals are suspected to be the mediators of the effects of temperature, osmolarity, and nutrient levels, on cells (Nagarathnamma et al., 1997; Osbourn et al., 1990), which are also important bioreactor environment variables. **Therefore**, free radicals can be expected to play a significant role in determining bioreactor productivity.

Note that in addition to the transition tools indicated in bold earlier, I had sub-consciously used repetition, when I framed the paragraph.

With this, the first paragraph that communicated (and not merely presented) the background was ready.

Second Paragraph

In a similar fashion, i.e., jotting down thoughts, ordering sentences and linking them, the motivation aspect could be communicated as follows in the second paragraph:

Xanthan gum is secreted by *Xanthomonas campestris* when it attacks plants (Cham-nongpol et al., 1995). The extent of xanthan gum secretion (mucoidy) is directly related to the pathogenicity of the organism on plants, which it attacks (Throne et al., 1987; Weiss et al., 1994). Pathogenicity is related to the induced oxy free radicals (Sutherland, 1991). **From an industrial viewpoint**, *Xanthomonas campestris* is employed for commercial bio-production of xanthan gum, which has wide applications in food, pharmaceuticals, oil, and other industries (Lee, 1996). If the relationship between free radical induction and gum production is better-understood, free radical induction may be employed as a means to improve xanthan gum productivity. **In addition**, a better understanding will help to improve cultivation strategies where oxygen is provided in situ through the liquid-phase oxygen supply strategy (Sriram et al., 1998).

If the two ‘completed’ paragraphs are read one after another, one can notice an abrupt jump in ideas between the two paragraphs. The first talks about free radicals, and the second, about xanthan gum. The aspects in the two paragraphs do not seem to be linked at all. This is not desirable, because

the reader, who is sub-consciously expecting a link, will experience discomfort when (s)he does not find one, and this in turn, would lead to a loss in communication.

Linking Paragraphs

In the context of the example, the relationship between free radicals and xanthan gum, especially from a production viewpoint, was unknown in the literature at that time. Therefore, known information could not be used to link the two paragraphs. Given this constraint, how did I link the ideas in the paragraphs?

The third sentence in the second paragraph talked about free radicals, and hence, it qualified as a connecting sentence. Therefore, bringing this sentence to the beginning of the paragraph, and suitably modifying the relationship expressed in this sentence was expected to help. This was indeed done, and let me present both paragraphs together with the modification in bold:

Free radicals are known to mediate a number of significant cell processes, including apoptosis and cancer (Feig and Loeb, 1994; Feig et al., 1994; Okuno et al., 1998; Reid and Loeb, 1993). Also, free radicals are suspected to be the mediators of the effects of temperature, osmolarity and nutrient levels on cells (Nagarathnamma et al., 1997; Osbourn et al., 1990), which are also important bioreactor environment variables. Therefore, free radicals can be expected to play a significant role in determining bioreactor productivity.

Oxy free radicals and oxidative stress are important aspects of plant defense mechanisms against invading microorganisms (Chamnonpol et al., 1995; Sutherland, 1991) such as *Xanthomonas campestris*, a plant pathogenic bacterium. Xanthan gum is secreted by *Xanthomonas campestris* **during its attack, and** the extent of xanthan gum secretion (mucoidy) is directly related to the pathogenicity (Throne et al., 1987; Weiss et al., 1994). From an industrial viewpoint, *Xanthomonas campestris* is employed for commercial bio-production of xanthan gum, which has wide applications in food, pharmaceuticals, oil, and other industries (Lee, 1996). If the relationship between free radical induction and gum production is better-understood, free radical induction

may be employed as a means to improve xanthan gum productivity. In addition, a better understanding will help to improve cultivation strategies where oxygen is provided in situ through the liquid-phase oxygen supply strategy (Sriram et al., 1998).

(These were indeed the first two paragraphs in the published paper [12]).

In a similar fashion, I could move forward, compose the other paragraphs, and link them to produce a coherent document.

To summarize, the important steps in the structured approach to improve coherence were:

Most importantly, the student needs to be knowledgeable in the area, and aware of the aspects that need to be communicated. Then, the student needs to:

1. Write down the points that (s)he needs to communicate in each section, as it comes to his/her mind.
2. Order them logically.
3. Improve coherence (by using tools).
4. Link paragraphs.
5. Link sections/chapters, if needed.

Effectiveness of the Structured Approach

The above structured approach was given to the students taking the communication skills course at IIT Bombay. In addition, they were given exercises to practice writing (and presentation). Their writing (and presentation skills) improved significantly. Students were thankful that such a course was offered to them. Some students who were comfortable with the language were initially skeptical about the utility of the course to them. Those students learned that effective communication does not necessarily arise from an ability to write correct grammar alone. Such students also said that they significantly benefited from the course. Many (15 out of 28) faculty members had, on their own, expressed their appreciation for, and satisfaction with the improvements in communication

that they had observed in the M.Tech. seminar course. In the seminar course, the students work on a research area, and present a critical evaluation of the literature through a written report, and an oral presentation. Six other faculty members said that the course was useful, after being asked for their input. No negative comments were received either from the faculty or the students, except, about certain individual preference based aspects on presentation style. For example, one of the faculty members did not like the student revealing parts of a slide at a time; instead he preferred the different parts on different slides.

In short, through clear thinking, and better organization of information that is based on a sensitivity to the reader's needs, better writing can be achieved. Very often, bad writing results from muddled thinking, and an inability to perceive the reader's needs. Further, writing is a skill, as is swimming. One cannot expect a person who does not know swimming to swim well with a set of verbal/written instructions alone; a lot of practice is required. Similarly, good writing requires a lot of practice, and the structured approach given in this article cannot obviate that requirement. But, it provides a clear direction for the practice.

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