GRAND WORDS, BUT SO HARD TO READ!

Diction and Structure in Student Writing

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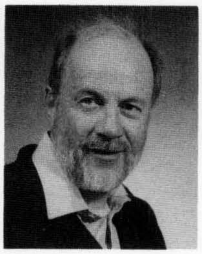
What makes student reports so hard to read? After all, students are a pretty competent lot, are they not? Can't we assume, therefore, that they write well too—that technical competence and writing ability go hand-in-hand?

Not at all.

The skill with which most students manipulate differential equations or design PID controllers is rarely reflected in the way they *write* about these things. Although few of them commit the worst faults (ungrammatical sentences, dangling modifiers, and heavy reliance on the passive voice), even the best students often produce muddled prose. Why?

The answer, we think, lies in two chief faults of student writing: sloppy, imprecise use of words and phrases and a disregard for the natural sequence of ideas that the reader expects. In this paper we will show, using examples of student writing, how even the most straightforward technical material can become confused, obscure prose when not enough attention is paid to choosing just the right word and to arranging ideas in a coherent manner.

How can we improve our students' technical writing? Merely pleading with them to choose and arrange their words carefully is not enough. We must first convince them that learning to write well is not only essential in communicating their ideas to others, but that it is also fundamental to the act of *learning* itself. Morton Denn, former editor of the *AIChE Journal,* said,[1] "Skill in communication is closely tied to the way in which an individual formulates and approaches problems, *and the failure of schools to emphasize writing has had a major impact on technical education and professional practice"* (our italics). His observation, though a little disheartening, suggests a tantalizing question that is certainly worth mulling over—by making our students better writers, can we also make them better engineers?



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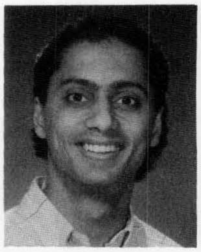

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THE PURPOSE OF TECHNICAL WRITING

How do Diction and Structure Fit In?

Now, what I want, is Facts . . . . Facts alone are what are wanted in life . . . . Stick to the Facts, sir!"
Thomas Gradgrind
in Charles Dickens' *Hard Times*

Students often forget that the purpose of technical writing is not merely to present facts and information, but also to *communicate* them. In other words, as Gopen and Swan put it,[2] "[it] does not matter how pleased an author might be to have converted all the . . . data into sentences and paragraphs; it matters only whether a large majority of the reading audience accurately perceives *what the author had in mind"* (our italics). To communicate clearly, effectively, and persuasively without misleading the reader, therefore, the writer must choose words carefully and structure ideas logically so that the reader knows precisely what is meant.

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Our choice of words and phrases, or *diction* in the language of grammarians, determines the accuracy and clarity of our writing. Proper diction might not seem, at first sight, to present much of a problem in scientific writing. After all, engineers and scientists write about concrete things—models, simulations, controllers, packed-columns, reactors— and how they work. Finding the right word or term should be easy, especially in the straightforward writing we demand of our students. But in technical writing we also describe, analyze, recommend, argue, and discriminate. To do these thing well and without ambiguity, we must be mindful of selecting exactly the right words. Yet, either consciously, to hide their ignorance, or unconsciously from sheer sloppiness, students often choose their words poorly, with the result that sometimes we don't know what they are trying to say, or indeed, whether *they* really understand what they are trying to write about!

Good diction, however, is only one ingredient of clear prose. We must also strive for coherence when presenting information or arguing a point. In student writing, ideas within a paragraph are often presented in a haphazard fashion, with no thread to bind them together. The result, as with poor diction, is confusion and frustration in the mind of the reader. No matter how carefully the sentences in a paragraph are crafted, the ensemble will mean little if there is no logical connection among its constituent units. To avoid confusion and to present ideas as smoothly as possible, the writer must be careful about *where* he places information within a single sentence and within groups of sentences. The arrangement of this material is what is meant by the *structure* of prose. In a well-structured paragraph, the beginning of a sentence looks back to what was just said, while the information at the end of the sentence represents new material that the author wants to introduce. In this way the reader always knows where he is in the exposition or discussion. Like Theseus, he always has his hand on the thread (here, the thread of the argument) and will have little trouble finding his way about even the most labyrinthine discourse.

In the following two sections we will look at some examples of student writing that illustrate what happens when words are poorly chosen and when the expectations of the reader about where information should appear are not fulfilled. The result is that even simple, straightforward technical material becomes very difficult to follow.

DICTION

> *Alice had no idea what Latitude was, or Longitude either, but thought they were nice grand words to say.*[3]
>
> Lewis Carroll
>
> *Alice's Adventures in Wonderland*

Student reports are often full of big, "scientific-sounding" words, some of which are chosen solely to impress the reader. Here is just one example:

> *Step tests were run to determine the boundaries of the problem statement (i.e., the valve positions at 75°C and 85°C).*

Grand words indeed, but what does "boundaries of the problem statement" really mean? Were the students really interested in characterizing the "problem statement" itself? Or, if we carry their words to the extreme, can valve positions have boundaries? Using pompous expressions or words can lead to absurd statements like the one above and can confuse the reader. After reading the sentence a couple of times, we still do not know why the students carried out step tests. Unfortunately, such inflated, imprecise prose is common in student writing. Consider the following:

> *Due to the stochastic nature of the conclusions of this study, no real difference between the two statistical methods could be ascertained.*

It is clear that the author found no difference (the word "real" is superfluous here) between the two methods, but *how* and *why* he came to such a conclusion remain a mystery. Indeed, if we are to take the author literally, rational enquiry is of little use to either him or to us—our conclusions themselves are subject to the laws of probability!

In the two examples just presented, the students used pretentious expressions such as "boundaries of the problem statement," "stochastic nature of the conclusions," and "ascertained" to project an air of unassailable authority. In the second example, however, there is another objective: to hide what the author thinks is a result for which he will be penalized. Instead of saying the obvious (something like "the two methods yield the same result"), he feels compelled to embellish such a simple, straightforward statement; in the end the effect is more comic than convincing.

Yet another group of students writes:

The same tuning constants [that we used in the simulation] were used with PID control on the actual process. The response was found to be less than excellent. . . . This indicates that the simulation is lacking in the heat rejection department.

The faults in this example are too numerous to list. We note, however, that here the students have managed to combine obfuscation with pomposity by using terms such as "less than excellent" and "heat rejection department." In addition, the second sentence is particularly confusing. Was the *response* of the process (to a step input, set-point change, etc.) poor, or was the *agreement* with the simulation poor?

As we stated earlier, poor diction confuses the reader and leaves him doubting the writer's grasp of the subject. For example, here is how some students described a computer simulation of a stirred-tank heater:

The system was modeled using two different simulations. One simulation was based on the Euler equation, while the second simulation was based on the Runge-Kutta #4 equation.

Nonsense. First, there may have been two simulations, but there was only one *model*, one set of differential equations. Second, numerical methods of integration do not form the basis of any simulation. Third, Euler, Runge, and Kutta wrote many equations; which ones do the authors mean? Here, the students are unsure of the meaning of the words *model* and *simulation;* hence, they "model" a system using a "simulation," and they base their simulations on numerical methods of integration!

In our last example we find the following:

The model is only as good as the system parameters as identified by the experimental tests. It is assumed that the process parameters found in the experimental tests are an accurate representation of the process.

Confusing? What if we replace the word *model* in the first sentence with *simulation?* Although the sentence is still faulty, we can now begin to understand its general meaning—something like "If the parameter *estimates* are unreliable, the simulation will be too!" In the second sentence, excess verbiage ("an accurate representation of the process") camouflages what we think is the authors' real intent: to say that the parameter estimates they obtained were indeed reliable. Here, as in the previous example, poorly chosen words and phrases leave us wondering how well the students have grasped certain fundamental notions such as the distinction between a model and a simulation, what parameters and parameter estimates are, and how engineers "represent" processes.

In most technical writing we would like to choose the right word to be as precise as possible, not to satisfy requirements of nuance, balance, rhythm, and subtlety. Technical terms usually have a single, precise meaning and cannot always be interchanged—if we mean "parameters" we should not say "parameter estimates," and if we are describing a "model" we should not use the word "simulation" in its place. At the same time, however, scientific prose is more than a mere list of technical words—it also requires verbs, adjectives, and adverbs. It is here that students are tempted to use vague, imprecise phrases, either out of a desire to obscure the real meaning or simply out of sloppiness. If students find that two different methods give the same results, they are not likely to choose the simplest words to say so but will write instead that "the two methods could not be differentiated" or "the two methods yield approximately the same conclusions." Choosing just the right word is hard work, but it is essential to do so to say exactly what is meant. Good diction enforces clarity, accuracy, and honesty in writing—essential components too of scientific investigation.

STRUCTURE

[Writers] should, whenever possible, prepare their readers for new information by beginning their sentences with a "topic," ideas that are familiar to the audience or that have already been referred to, and then moving to . . . newer, less predictable, less familiar information

By consistently choosing to arrange information in this way, writers . . . enhance the coherence of their documents . . . .

J. M. Williams[4]

Most technical reports are divided into logical units called sections. For example, a typical document might be structured in the following manner: Introduction, Experimental Method, Results and Discussion, and finally, Conclusions and Recommendations. Not only do most readers expect this structure, but it also provides a framework in which the writer can logically present an analysis or argument. Imagine, for example, trying to read a discussion of results before any results have been shown!

Just as a report is arranged into logical units, so too can a sentence be divided, although its functional divisions are not explicitly labeled.[2] This way of looking at the structure of prose has been formalized in a linguistic principle known as *functional sentence perspective.* In brief, it states that a sentence should begin with a "topic" idea, information that is familiar to the reader, and then move on to the "stress position," an idea or information that is less familiar, more complex, and more important[4, p. 93]. Organizing a sentence in this way not only makes the flow of ideas more coherent and less choppy, but it also ensures that the reader understands exactly what the writer is trying to emphasize.

The expected structure of a sentence can be portrayed very simply as

Expected Sentence Structure		
Topic position →	verb →	stress position
(refers to old information)		(new information)

The first part of the sentence (the topic) refers to a particular subject and looks backward to ideas that have already been presented, usually in the preceding sentence. New information is then located toward the end of the sentence (the stress position). This repeated overlapping of the new information in one sentence by the topic of the next s uggests, we think, a particularly apt metaphor—the laying of shingles. By "shingling" his sentences in this way the writer can lead the reader from start to finish, from premise to conclusion, in a methodical manner.

What happens when we violate this principle? Take a look at the following example of student writing in which the authors paid little attention to the smooth flow of ideas.

The chemical engineer is often faced with the problem of analyzing the relationship between two large sets of process data. In the past, multivariate statistical methods have primarily been applied in the social sciences. Due to the large amount of data generated by industrial processes, chemical engineers need these types of statistical tools. The purpose of this report is to investigate two different methods . . .

Each sentence above makes sense when read by itself. Strung together in the way they are, however, means that we have to read the passage several times before we can understand what the authors are trying to say: that for certain types of statistical analyses, chemical engineers need tools that, until now, have been used mainly in the social sciences.

Why is the passage difficult to follow and to understand? The first sentence sets up certain expectations in the reader's mind about what is being discussed—the analysis of large sets of process data. In the second sentence, however, we are confronted with new information ("multivariate methods in the social sciences") that has no connection to what we have just read. At the end of the second sentence we move on to the third with the term "social sciences" fresh in our minds—but again, we encounter a topic ("data generated by industrial processes") that has nothing to do with what we have just read. By violating the reader's expectations of what he *expects* to read at each step and by beginning each sentence with a topic that does not refer to old information, the authors have written a passage that has no focus.

In the second example, another group of students writes:

Over a period of time, weak acids, sodium mercaptides and sodium sulphides accumulate in the prewash caustic, requiring the spent caustic to be replaced periodically. A strong odour in the spent prewash caustic indicates that the process is running inefficiently. In the #1 plant, when the caustic needs to be changed, the column is completely drained of spent caustic and replaced with fresh caustic. When the caustic is dumped it is sent to a spent caustic storage tank.

Here, as in the first example, we can understand the individual sentences, but we have no sense that anything ties them together. The reader is confronted in the topic position of each sentence with completely new information. Thus, going from start to finish occurs in a series of jerky movements, and we are not sure just what the writers are trying to emphasize.

The above discussion of expected sentence structure presents a much simplified picture. For example, the topic may refer to an idea farther back than the preceding sentence. Furthermore, the size of the stress position can vary quite a bit. In some sentences it may be as short as a single word, while in others it may extend over several lines.[2] Nevertheless, if the writer follows the simple paradigm pictured above within single sentences and within groups of sentences, the reader will be able to follow, with little effort, the flow of the argument. The following example illustrates this point:

In suspension polymerization the conversion of monomer to polymer takes place in the aqueous phase. At the end of the reaction, the slurry contains not only polymer and monomer but also emulsifier and other water-soluble impurities. Because these impurities affect the quality of the final product, they must be removed from the polymer. Thus, the method of drying the polymer is of prime importance.

The first sentence introduces the general subject (suspension polymerization) which, as the author informs us, takes place in the aqueous phase. The emphasis on water is followed by putting the word "slurry" in the topic position of the second sentence. The focus then shifts, in the stress position, to water-soluble impurities, and these reappear in the topic position of the third sentence. As the third sentence unfolds with a dependent clause ("Because these impurities . . ."), we begin to sense that something important is coming up, and by structuring the sentence in this manner the author makes it clear to the reader that it is important to remove

Continued on page 209.

Grand Words

Continued from page 203.

the impurities from the final product. The final sentence, then, which states the subject of the report, appears as a logical consequence of what has come before. Indeed, we might say that it occupies the stress position of the entire paragraph itself.

Although the previous example fits quite neatly the paradigm outlined above, mere mechanical application of the "topic → verb → stress" pattern in each sentence of a paragraph cannot guarantee coherence. The author must decide, for example, whether the reader is capable of making a connection between the material in the stress position of a sentence and the topic position of the next. The link may be obvious to the writer, but if it is not clear to the reader the thread of the argument may be lost. In the example cited above, the author is writing for an audience of chemical engineers; it is taken for granted that the word "slurry" appearing in the topic position of the second sentence will be recognized by most readers as referring back to the term "aqueous phase" which appeared in the first sentence.

Up to this point we have emphasized only the author's responsibility to write coherent prose. However, just as searching for the right word forces a writer to think hard about what he really wants to say, so too can thinking about how best to structure an argument compel the writer to re-examine the logic, coherence, and clarity of what he is trying to communicate to the reader. This link between clear writing and clear thinking is a theme that we take up in the final section.

CLEAR WRITING AND CLEAR THINKING

Ce sont les mots qui conservent les idées et qui les transmettent, il en résulte qu'on ne peut perfectionner le langage sans perfectionner la science ***ni la science sans le langage.*** *[emphasis added]*

A Lavoisier
Traité élémentaire de chimie

(It is words that preserve and transmit ideas. As a result, we cannot perfect language without advancing science, ***neither can we advance science without perfecting language.****)*

For most students, writing clear, precise, logical prose is never an easy task. They look upon report writing as a loose end to be tied up after the *real* (meaning *technical*) work is done. Consequently, they give little thought to technical communication. Small wonder then that student reports are frustrating to read, that they contain poorly chosen words and phrases, that ideas are haphazardly thrown down on paper. Yet, as we stated at the beginning, students *are* technically competent. They *can* develop mathematical models and simulations without knowing the distinction between the two terms. Are we being merely pedantic, therefore, by insisting upon good diction and coherently written paragraphs? Is writing ability simply a *desirable*, but not an *essential,* element of the engineer's art? We don't think so, for two reasons.

First, although student prose may be confusing, instructors can usually decipher it—but only because they supplied the topic or problem in the first place and are probably familiar with it. When students become practising engineers, however, their audience may not be so well-acquainted with the subject. Thus, not only does sloppy writing automatically place their ideas and arguments out of reach, but it can also jeopardize their careers. An engineer who writes incomprehensible prose is in danger of being passed over for promotion in favour of someone who *can* write clearly, logically, and precisely.

Second, clear thinking begets clear writing. In other words, the better we understand our subject, the better we will be able to write about it. However, careful writing can also help us clarify and understand the ideas that we grapple with. Except in those rare instances when we come to a visceral understanding of something almost immediately, most ideas and notions circulate about in our heads in a vague, half-baked form. Only when we are obliged to write them down, to explain them, and to justify them do we really force ourselves to think deeply and logically about them.

For the engineer or scientist, therefore, writing serves two purposes: to communicate our ideas to others, and, perhaps more important, to help us get those ideas straight in our own minds. Thus, we must emphasize to our students that learning how to write clear, precise prose is just as much a part of their technical education as learning how to solve differential equations. The ability to write well is an essential ingredient in developing a logical scientific argument and, as the epigraph to this section makes clear, it is therefore *fundamental* to our craft.

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