Public Speaking and Technical Writing Skills *for Engineering Students*

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LAKESHORE PRESS

PUBLIC SPEAKING AND TECHNICAL WRITING SKILLS FOR ENGINEERING STUDENTS

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Woodsville NH

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Woodsville NH 03785
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In memory of Eric I. Pas

A NOTE TO THE STUDENT

Michael Polanyi, a distinguished scientist-turned-philosopher, is well known for having developed a theory of thinking called "tacit knowing." In essence, he suggested that we know a great deal more than we will ever be able to express in words. We are able, for example, to recognize immediately a look of puzzlement on a person's face, yet we are unable to describe what tells us that the look represents puzzlement. The specifics we cannot describe, but the overall effect is tacitly understood.

In engineering and science such tacit knowledge represents hunches and intuitions that lead to new advances in the application of knowledge for the benefit of humans and the environment. Without the ability to channel tacit knowledge into creative thought, engineers and scientists would not be able to derive advanced technology from fundamental principles.

The most frustrating part about such knowledge is the difficulty of communicating it to others. And yet, without question, a fundamental requisite of effective engineering is the ability to convey information using verbal skills. There appears to be a large gap between the information we know and the information we can communicate.

The objective of this book is to help close this communication gap. At Duke University, we have used the material in this book in a required civil engineering course and have consistently received positive feedback from our graduates who acknowledge that these skills are indeed useful and valuable to them in their professional practice. The graduates invariably recommend that even more time be spent in the development of verbal skills during the undergraduate engineering education.

No matter how well we learn engineering communication, however, Polanyi's sobering theory will always be a source of frustration and consternation. Nobody will ever be able to write, tell, or draw everything he or she might know. This should not, however, deter you from developing your skills in the art and science of engineering communication to the highest level practicable. You'll never crash through the barrier of "tacit knowledge," but I am confident that improved verbal skills will significantly enhance your engineering education and promote your professional career.

A NOTE TO THE INSTRUCTOR

The last chapter of this book is a discussion on ethics. This is not to imply that professional ethics deserves less attention than the material on speaking and writing. Rather, it is packaged together to afford an opportunity for a general discussion at the end of the course, where the substantive material has been covered and where a period of reflections might be appropriate. At Duke I discuss the content of this chapter in three class periods and I also introduce some of the ethical concerns of engineering communication throughout the course. An alternative method of using this chapter is to introduce the appropriate section on ethics immediately following the chapters on speaking and writing. Either way, I believe that ethics represents a major part of an engineering education, and this course offers a wonderful opportunity to engage students in discussions of ethical issues.

An instructor's manual is available which includes answers to the problems and recommendations for interactive laboratories. This manual is available through Lakeshore Press, P. O. Box 92, Woodsville NH 03785.

ACKNOWLEDGMENTS

Recognizing that the ability to communicate often dictates the success or failure of a professional engineering career, the late Professor Eric Pas of the Department of Civil and Environmental Engineering and I developed a course for the Duke University engineering curriculum that covers technical writing, public speaking, engineering drawing, and computer graphics. For over ten years we spent many hours discussing the sequence and value of the material in this course. And some of his insights have no doubt permeated my own thinking, and have therefore found their way into this book. I will always be grateful to him for sharing his communication skills with me and for being the best friend a person could ever hope to have. It is thus with appreciation that I dedicate this book to his memory.

This book was finished when I was on sabbatical leave at Bucknell University. The hospitality of Jai Kim, Chair of the Department of Civil Engineering, and Joseph Humphrey, Dean of the School of Engineering, is very much appreciated.

The manuscript, in various stages of preparation, was read by several people, most notably by my brother, Priit Vesilind, my daughter, Pamela Vesilind, and by my stepson, Christopher Endy. As a result of their suggestions and criticisms the book has been greatly improved, and I have become, I hope, a better writer.

Finally, my thanks to the students in EGR 150 at Duke University who, with their suggestions, have helped shape both the format and details of the course and greatly improved this textbook.

PAV
Bath NH
1999

engineering's discipline

into the discipline with eyes wide and knees weak
anxious to travel this unknown and foreign path
obscured by tedium and hard work
striving and enduring to attain some level of success
with a stout-hearted outward appearance
to mask the weariness and vacillation
repressing the self-doubt – learning self-discipline and sacrifice
while hating the lesson
all-the-while steadily moving forward
with a growing self-confidence and determination
demanded by this nebulous journey
to the ordained destination
to realize these trials were the gifts of the path.

Virginia Feigles
BSCE '99 Bucknell University

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CHAPTER 1

TECHNICAL WRITING

Life is an essay question, not a True or False test! We are continually called on to explain in words our ideas, our wishes, and our emotions. Verbal communication is as essential in engineering as calculus or mechanics -- and learning to write and speak well is a prerequisite for a successful engineering career.

There are two reasons why engineers should learn to write well. The first, and most obvious one, is that writing is one of the engineering languages with which one person communicates information to another person. For many years this was thought to be the sole purpose of technical writing -- to write in such an unambiguous manner that the meaning could not be misunderstood. This is still a valid purpose, but it now joins a second more subtle but equally important reason for verbalizing information. The process of writing, or putting thoughts into words, is also a *learning* process for the writer. Writing crystallizes unorganized thoughts that have been rattling around in the head and this process of organization produces ideas and concepts that might not have otherwise been articulated. Thus good technical writing not only conveys information in an unambiguous manner but also serves as a means of thinking. Engineers often almost apologetically say "I can't think without a pencil," and use the doodles as a graphical thinking tool. The same is true for verbal language and the more developed the verbal facility the better the thinking process.

In this chapter I discuss the four different types of writing and then examine the formats or types of engineering documents usually encountered in practice. Following a short discussion of technical writing style, we look at the actual process of writing -- the "how to do it" step.

1.1 WRITING MODES

Types of writing can be divided into an almost infinite number of categories. One useful definition of various types of writing is suggested by Houp and Pearsall.[1] According to them, all writing can be categorized as:

- Exposition
- Narration
- Description
- Persuasion

Most written documents contain some aspects of each category and understanding each of these four can make your writing more effective.

1.1.1 Exposition

Expository writing clarifies, explains, instructs, puts forth, or exposes some material. Its purpose is to share information with the reader. Expository writing works best when the writer uses certain rhetorical devices already familiar to the reader, including topical arrangement, exemplification, definition, and comparison.

Topical Arrangement. To communicate a large amount of material, the writer can break down the substance of the material into an organized topical arrangement. For example, this book is broken down in such a manner, with individual chapters and subheadings. Imagine what this textbook would have looked like if it were a complete mishmash of all the information in a totally unorganized manner.

The procedure for achieving a proper topical arrangement is the *outline*. You probably have been writing outlines since the third grade, often without understanding the real purpose of these exercises. The outline is nothing more than a topical arrangement that makes the material easier to write and makes the written work more readily understood by the reader. To work best, the outline should have several necessary attributes:

- The outline should display a logical progression of ideas.
- Headings should be of equal weight.
- A series or headings should be of one classification.
- Topics should not overlap.
- Divisions should be of sufficient size to incorporate meaningful information.

Often a good method of topical arrangement is chronology; the use of time as a variable. In other cases space is useful. For example, if it is necessary to describe a flower garden, either time or space can be the variable. If time is used the exposition starts with the first flowers to appear in the spring and moves through the seasons. If space is used, the garden at any given time can be described according to what flowers appear from one end of the garden to another. These are not necessarily the only topical arrangements, of course. A lovely description of a garden is possible by invoking neither time nor space as a vehicle but choosing color instead. If the purpose is to describe a garden, the writer should first imagine as many topical arrangements as possible and then, after choosing one, remain consistent.

Exemplification. Always be careful to provide an explanation for statements that leave some question unanswered. For example, the statement "The grades in this course last year were too low," demands more information. *How* low? Compared to what other course? Please explain yourself. Exemplification is a technique where a general statement is made first, followed by explanations that provide the specific material. Without the explanations the statement is of little value.

Definition. One of the most difficult tasks in technical writing is the adaptation of the written material to the audience. If the audience is made up of one's colleagues the language would be very different from the language used in an engineering report to the elected officials of a community. Which words or symbols need definition and which do not? If the report includes the word "odometer," for example, should it also include the definition "an instrument in a car used for measuring distance," or is it possible to depend on the audience's knowledge of automobiles?

The reader's knowledge of symbols is also difficult to gauge. For example, the letter Q is universally (well, at least in the U.S.!) used as a symbol for flow rate. But only engineers would know this. So if flow rate is used in a discussion for non-engineers, the words "flow rate" should be spelled out, or if Q is used, it should be defined from time to time. Further, flow rate can be in many units (e.g. million gallons per day, cubic feet per second, and even some abominations such as acre-feet per year). The reader who is not educated in the discipline could not guess what MGD or cfs mean -- terms familiar to most engineers. In writing definitions it is wise to err on the side of redundancy.

Comparison. Comparisons, especially analogies or metaphors, are powerful rhetorical devices. Visualizing electricity in terms of fluid flow is an old comparative device for achieving a better understanding of electrical current. Describing a fabric filter in an electric power plant as a big vacuum cleaner can be helpful in explaining the concept to a non-technical audience. Analogies compare one situation or thing to another, often using words such as "like" or "as." For example, "Cleaning house when your children are still home is like shoveling the sidewalk when it's still snowing," (Attributed to Phyllis Diller), or Calvin's observation that "One inch of snow is like winning 10 cents in the lottery," (*Calvin and Hobbes* comic strip).

Metaphors, on the other hand, invoke a situation that can be useful in attaining a deeper meaning but are not direct one-to-one analogies. For example, the sentence "The chemical engineering curriculum is a salad bar of courses," uses salad bar to describe the curriculum. In ordinary language, salad bar describes one thing, but as a metaphor it is applied to another (the curriculum) without expressly indicating the relationship between the two.

In summary, expository writing conveys information using rhetorical devices such as a proper topical arrangement, adequate exemplification, useful definition, and effective comparison.

1.1.2 Narration

Why do many public speakers start their presentation with jokes? The reason is, of course, that jokes tend to "warm up" the audience, to establish a rapport between the speaker and the audience. But why a joke?

A joke is a story, and storytelling, or narration, is the oldest form of information transfer. When we were young, we all listened to stories, and storytelling is a very enjoyable form of communication, even for adults.

Narration takes place when at least some of the following parts are present:

- time -- "Once upon a time..."
- place -- "in a land far, far away..."
- characters -- "there lived a beautiful princess..."
- plot -- "who wanted to study engineering."

In engineering writing narration is not often used since most information does not lend itself to story form. The one exception might be literature surveys used in academic dissertations, which often take the form of stories of how a certain process or piece of knowledge came to be known. In these cases the narrative starts with a time, a place, with characters being the researchers, and the plot being the mysteries of the problems. Another narrative might be the telling of how a final design was arrived at. For example, "We first tried mild steel, but discovered that the acidic environment was too harsh. We then decided to use stainless steel."

1.1.3 Description

Descriptions convey information through the five senses: sight, hearing, taste, touch, and smell. Descriptions can be part of either expository writing or narrative. Analogies and metaphors are often used in descriptions. Consider how the following sentence relies on our senses for communicating information:

> The aeration basin at the wastewater treatment plant foamed over, producing billowing masses of acrid foam that were picked up by the wind and carried hundreds of yards downwind like huge, dirty clouds.

The analogy to clouds is useful and describing the foam as dirty and acrid (sight and smell) invokes a negative image, just as intended.

Descriptions can be greatly enhanced by comparisons to familiar objects. Since we visualize in five ways -- size, shape, color, texture, and position -- a wide range of comparisons is available.[2]

For example, the size of an object can be compared to a coin (such as a penny), a typewriter, a car, or a tennis court. The shape of an object can be described geometrically as circular, square, cylindrical, L-shaped, or tubular. Often the shape can be related to known shapes such as a pencil, or a table, or a spider. Texture can be described as smooth, rough, coarse, or glazed, while position can describe the object in relation to other known objects, such as behind the chair or parallel to the road. The objective in descriptive writing is to use as many of these comparisons as necessary in order to convey the most accurate representation of the object in words.

In some instances, a seemingly accurate description is insufficient if unwarranted assumptions are made about prior knowledge or if the words have several meanings. For example, an Englishman might describe the game of cricket in this manner:

> You have two sides; one out in the field and one in. Each man that's in the side that's in goes out and when he's out he comes in and the next man goes in until he's out. When they are all out the side that's out comes in and the side that's been in goes out and tries to get those coming in out. Sometimes you get men still in and not out. When both sides have been in and out including the not outs, that's the end of the game![3]

Even though this is an accurate description of the game of cricket, it is very difficult to follow because simple worlds have different meaning.

1.1.4 Persuasion

One way of describing persuasion is:

> The purpose of persuasion is to convince the reader of a view. ... a conscious effort by a sender to change the opinions, attitudes, beliefs, or behaviors of a receiver through the transmission of a message. Based on thorough audience analysis, persuasive writers select, order, and word the elements of their message so as to encourage desired responses in their receivers. Persuasion does not coerce; the receiver is free to choose.[4]

In engineering, technical decisions are sometimes not open to argument (e.g. "This span requires a 10WF30 steel beam.") but often they are open to many solutions (e.g. should the bridge be of concrete or steel?). Engineers who develop what they believe would be the most appropriate solutions for a given problem must convince their colleagues and client that their idea is indeed the best solution.

There are two basic techniques for organizing a persuasive argument:

- State the conclusion first, then fill in the details
- Begin by getting the reader to agree with the details, one at a time, and then present the conclusion.

These two methods are illustrated in Figure 1-1. In the first instance, the conclusion is stated at the outset, followed by filling in the argument. In the second instance, the argument is built up in a stepwise way so that the reader agrees with every step and cannot then fail to agree with the conclusion.

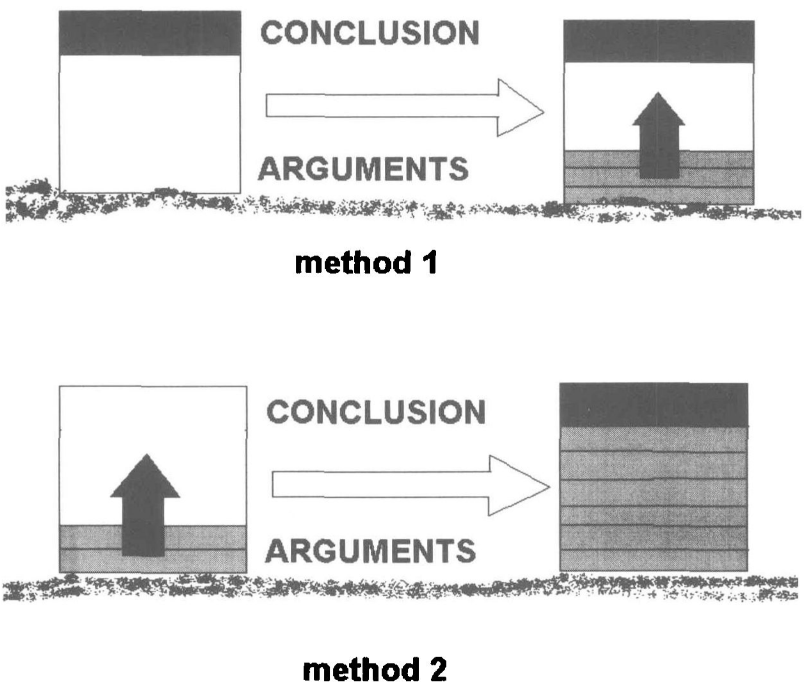

Figure 1-1 Two approaches to persuasion: 1. State the conclusion, then provide supportive arguments, 2. Present arguments leading to the conclusion.

The placement of the concluding statement either first or last takes advantage of two important rhetorical techniques -- *primacy* and *recency*. Audiences remember best the first sentence of each presentation since this is their first idea of what is to be presented (primacy), and the last sentence, since this is the most recent in their memory (recency).

For example, suppose the engineer is trying to convince the management to enter into a new product line, to manufacture and sell yo-yos. The engineer could start the presentation by saying, "We should start a new product line, manufacturing and selling yo-yos." This forthright statement would get everyone's attention, and the engineer would then follow with the details of the argument.

Conversely, the engineer could begin by saying "Our company wants to make a profit. Our competition is making a profit by selling yo-yos. We could make better yo-yos than anyone else...," concluding with the statement: "We should start a new product line, manufacturing and selling yo-yos." Placing the conclusion at the end also has the advantage of producing the least opposition since it starts with facts with which nobody disagrees and ends with a conclusion based on these facts.

Written argumentation is subject to numerous fallacies that can significantly detract from the force of the argument. Both writers and readers of technical documents should watch out for:

- Implied or questionable assumptions
- Begging questions
- Absent or faulty causation
- Non sequiturs
- Misuse of numbers and statistics

Implied assumptions include those made about the level of knowledge the reader has about the material. For example, proving a theorem using calculus is not very persuasive if the reader is not familiar with calculus. Sometimes implied assumptions are intentionally misleading. Political campaigns are notorious for this technique. Showing the candidate riding a horse on his ranch, wearing a red checkered wool shirt and jeans, leaves the (incorrect) impression that he *must* be sympathetic to environmental concerns.

Begging the question occurs in cases where proof is necessary but the conclusion is simply assumed. "When are you going to stop cheating on your taxes?" is a classic example of begging the question.

The **lack of cause and effect** is perhaps the most insidious fallacy and bombards us on a daily basis. The implied cause may have no bearing on the effect, or there may be many other possibilities. For example, the statement "I didn't get an A in this course because the professor doesn't like women engineering majors," implies that the professor does not give A grades to