Engineering Communicatio

Second Edition

Hillary Hart

SOURCE

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HILLARY HART
Department of Civil Engineering
University of Texas at Austin

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CHAPTER 1

Engineering and Communication

Objectives

By reading this chapter, you will learn the following:

- why writing and speaking well are critical to your success as an engineer;
- how writing and speaking can help you better understand your work as an engineer;
- for whom you will be writing at different times;
- why it is your ethical and professional responsibility to present data in a useful format;
- how to write different parts of a document for different audiences.

1.1 I AM AN ENGINEER, NOT A PROFESSIONAL COMMUNICATOR

Maybe nobody has told you yet, but the truth is this: To be an engineer is to be a technical communicator. Engineering is a problem-solving profession, and clear communication leads to effective solutions. As an engineer, you will solve problems for people (often, large groups of people). Whether your specialty is civil, mechanical, electrical, chemical, biomedical, computer, aerospace, or any other engineering discipline, you will develop products, services, and environments needed by some segment of the public. In order to produce those goods and services, you will work collaboratively with dozens of other engineers, experts, and support personnel, designing, analyzing, refining, and building solutions. You, your collaborators, and your clients will have to understand exactly what each of you is doing every step of the way. That is why communication skills are critical to engineering work.

Communication means writing, speaking, and showing visuals to other people, as well as listening to and observing others and reading their work. Of course, most of us think of writing as the most difficult skill to master (although, for some of us, speaking in front of a crowd seems not only difficult, but also terrifying). Yet, writing well is critical for communicating your ideas and solutions. Let us say you have designed a new type of bus shelter for a large city in a rainy part of the United States. Your design is rendered very professionally, either in CAD or as an artist's rendering, and you have submitted the design to the municipal transportation authority. In addition to presenting the design (see Figure 1.1), you will want to explain in a proposal the main features of the design and the criteria you used to develop it, such as the following:

- Keeps out rain effectively
- Allows enough openness to discourage theft and crime
- Trash does not collect inside

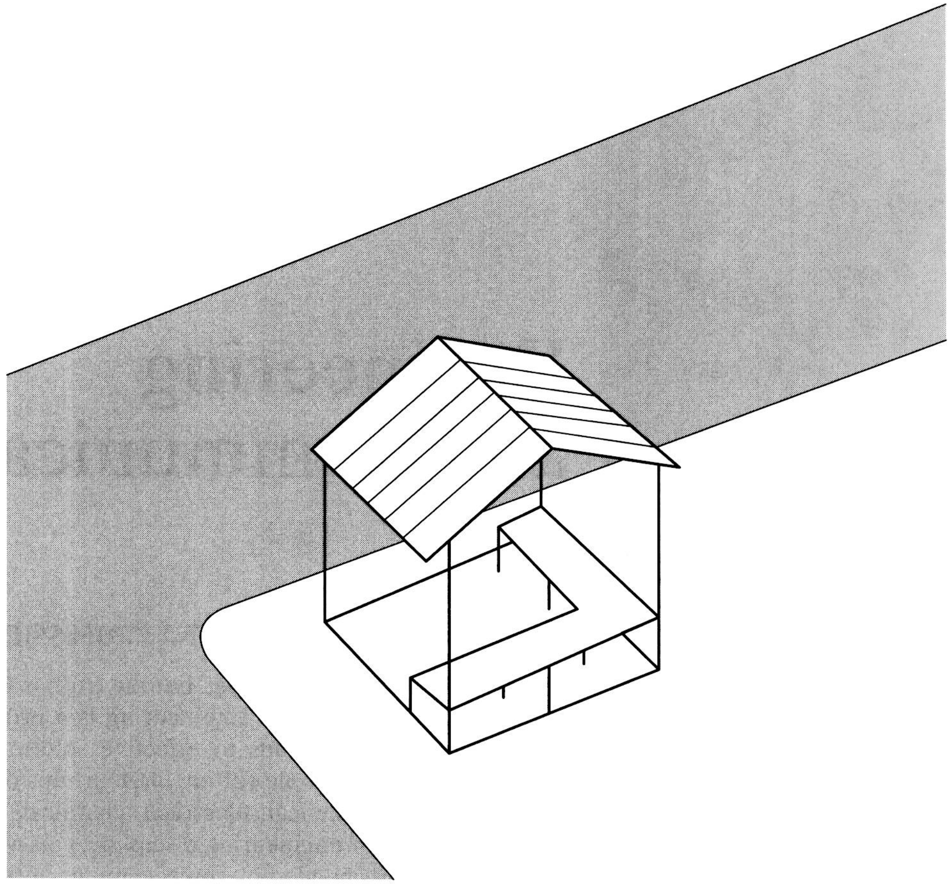

Figure 1.1
Artist's rendering of proposed bus-shelter design.

You will use pictures and words to argue that this design should be accepted and built. You may also include a line graph displaying the drop in bus-shelter crime experienced by another city that adopted a similar design. But your design improves on the previous one by being less costly: It can be assembled away from the site and installed on-site within a matter of hours. Sounds good . . . but only as good as you make it sound with your words and make it look with your visuals.

Communication is a part of almost every phase of engineering work. This chapter presents some basic tenets to remember throughout your career.

1.2 WRITING DEMONSTRATES MY COMPETENCE AS AN ENGINEER

Someone can point to a proposal you write for, as an example, a new type of bus shelter and say, "See what a good solution this is; see this clear explanation of how this design solves the problems." Your competence as an architectural engineer is proven by that proposal. The same concept is true for all the engineering disciplines. Inside your own organization as well, writing demonstrates that you understand the work you do and the jobs of the people with whom you work. Even your informal writing, such as memos and e-mail messages, demonstrates this understanding. When you give people truly useful information, you have shown that you know how they will use that information; otherwise, the information would not be useful. People read information in order to discover what they need to do. Whether your intention is to persuade or to inform people, your writing must clearly show them what actions are suggested or required.

RESEARCH SHOWS . . .

Readers often understand technical writing by forming a "concrete story or event" in their mind. They do this with even the most technical of documents, because they need to *use* the information in some way. They need to know "agents and action." So, the readers in one study actually rewrote a report by *restructuring* the information to be more active (Flower et al., 1983, p. 45).

1.3 WRITING AND SPEAKING CAN HELP ME DISCOVER WHAT I REALLY THINK

In the process of producing solutions, you will use many different kinds of oral and written communication. As you move through your career, no matter where you work—whether a large Fortune 500 firm, a small consulting firm, or a public agency—writing and speaking can help you plan, develop, and revise your engineering solutions. Writing can solve problems for you as well as for your reader.

Imagine, for a moment, that you must do some research for your boss on nanocrystalline coatings that protect microchips. There are many of these new coatings on the market, and your company needs information on similarities and differences among coatings before investing research-and-development time and money in adapting a coating for use on its chips. What do you do? How do you start? You probably start by reading as much as you can, collecting information on coatings and trying to organize it. Then you have to look for similarities and differences and make judgments about which coatings fit better with your company as products. How do you capture what you are learning? You probably take notes and make summaries of informative articles and websites. So you are already writing, even before you have started drafting the report you have to produce. You are also probably talking to people, asking questions and getting their feedback on your findings.

KEY IDEA: Writing drafts helps you see your own thoughts in front of you, so you can clarify and complete them.

When you do start drafting the report, you probably begin with the lists you have been making of each coating's qualities (strengths and limitations). If you do not have enough information about a particular coating, you will notice, because your list will not be complete. The simple act of putting down words shows you what you need to find out more about. And as you start drafting and making an argument for one kind of coating over the other, you may notice that you never say why, for example, coating 3 will not work. Your argument is thus not complete, because you had assumed early on in your investigation that coating 3 would never work, but forgot to explain why. And then when you start to explain why, you realize that you were mistaken about one of the attributes of coating 3, and it might work after all.

In these and many other ways, writing helps you see your own thoughts in front of you, so you can clarify and finish them. Without writing, you probably cannot know what you understand and what you do not. Just remember that writing happens over time, as a recursive process of outlining, drafting, and revising. You have to give it time. Computers can help us create and revise documents faster, but they probably cannot help us think faster. And your writing is simply the clear arrangement of your thoughts—after you have rearranged them a few dozen times. Remember that when you see someone else's writing, you are seeing a final product; you cannot see the hours of drafting and thinking that went into that written product. So, do not think that most people write faster than you. Almost no one writes very quickly!

EXPERTS SAY . . .

According to engineer Henry Petroski, there is a clear connection between the practice of engineering and the practice of writing, since both involve creating something new: "Writing no less than engineering consists of ideas to be realized" (p. 10). In his book *Beyond Engineering* (1986), Petroski draws a parallel between an engineer as a bridge builder and as a writer when he describes an engineer as "the designer of a bridge of words" (p. 10). He also explains how writing about bridge building helps the engineer understand the actual process of bridge building better, because writing is "the test of an engineer's understanding of his own theoretical work" (p. 11).

1.4 MY READER OR LISTENER (MY AUDIENCE) IS ALWAYS MY CLIENT

As an engineering professional, to whom will you be writing and speaking? Those of you who have worked in engineering-related firms, private or public, know that, as an entry-level engineer, you make reports (orally and in writing) to your boss, to colleagues, and sometimes to middle managers from other divisions or offices. For the first few years of your career, you probably will not be writing directly to outside clients. In fact, one survey found that, three years after graduating with a B.S. degree, most engineers were writing more often to people inside their organization than to people outside it (Anderson, 1986). So, in light of this finding, why should you consider your reader a client? Because the other finding from this study was that most of those in-house readers knew less than the writer about the subject matter. So, if you are the writer, your job is to help your readers understand the subject matter and act on that information.

Treat your reader or listener like a valued client—someone with whom you want to maintain a positive professional relationship. And think about how to talk to that client, in writing or by speaking. For example, suppose that you have to present that design for a bus shelter to the city council. How do you explain a design to people who may not look at designs very often? City councils are usually composed of ordinary citizens from many walks of life who happen to care about their city. Do you show them a plan view of your design? A schematic? Will your readers know how to "read" these visuals? Should you refer to the "postmodern use of space"? Will your readers understand that terminology? You would want to examine your communication options ahead of time, including vocabulary, visuals, and even tone of voice.

RESEARCH SHOWS . . .

In the workplace, chances are good that you know more than your readers—even in-house readers—about the subject matter of your writing (Anderson, 1986). This means that you must explain technical processes, concepts, and vocabulary more than you might think.

1.5 IT IS MY ETHICAL RESPONSIBILITY TO TURN DATA INTO INFORMATION MY READERS CAN USE

Engineers deal with lots of data; they collect and generate test results, experimental results, specifications, standards, all sorts of numbers, and raw facts. In order to make your communication useful for all your readers and listeners, you need to help them understand the meaning and the relationships of your data. Data are just raw facts. For example, consider the statement, "It is 100°F outside." That piece of data will not be very informative to a child who does not understand what "degrees" means or to a visitor from Indonesia who is not familiar with the Fahrenheit system. Data are bits of information (test results, raw facts) that must be interpreted, organized, and synthesized in order to make sense and to have meaning. As one cognitive scientist put it, "Data plus meaning is information" (Reeves, 1996). Your job is to turn the data you produce into useful information by anticipating the needs of your reader. Sure, many of your readers will be technical professionals like you, but they still need to know the relationships among the data you present.

KEY IDEA: Data are raw facts/numbers; information is data made useful for someone.

The information, for instance, that air density changes with temperature can be demonstrated by presenting the correlation between air density and temperature at successive measurements. You would probably use an x–y scatter graph, with a line drawn through the series of points plotted, to convey this information, as in Figure 1.2. If you chose, on the other hand, to convey the information in words alone and presented the temperature readings in one paragraph and the corresponding density readings in another paragraph, you would make it way too hard for the reader to perceive how rapidly air density changes with temperature (especially by contrast with water density, for instance). And you would be very far from imparting knowledge to your reader that he or she could use later on. The x–y graph provides the best context (a visual context) for the reader to understand the correlations. And then your words can enhance and support the visual context: "At standard atmospheric pressure, the density of air drops steadily with increasing temperature." Graphical and verbal presentation of data, working side by side—bingo, you have created information your reader can use.

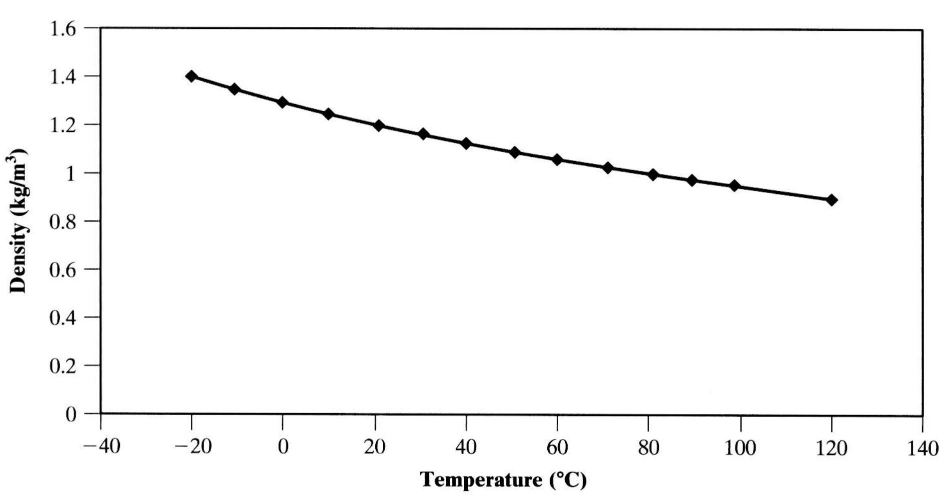

Figure 1.2
Relationship between density and temperature of air at standard atmospheric pressure. *Source of data:* Crowe, C.T., et al. 2001. *Engineering Fluid Mechanics*, 7th ed.

At this point, you might ask, "Why is communicating clearly an *ethical* responsibility?" In fact, the history of technology development is littered with examples of failures brought about, at least partly, by inadequate communication among engineers, management, and others. Edward Tufte and other researchers have written extensively about the communication problems between Morton Thiokol, the rocket manufacturer, and NASA in the hours preceding the decision to launch the space shuttle Challenger on a cold January morning in 1986. The Challenger blew up 73 seconds after takeoff, killing seven astronauts aboard (including the first woman in space, Christa McAuliffe). The analysis Tufte performed on the charts sent to NASA by the engineers the day before the launch is quite convincing: even though the engineers originally warned against the launch, because of possible trouble with the O-ring seals in cold weather, the charts failed to convince NASA not to launch. Even Morton Thiokol management later reversed their conclusion not to launch. The cause of the eventual catastrophe was actually debated by all those technical professionals on that fateful evening, but they failed to make the correct decision. Why? The charts prepared by the engineers failed to convey the danger clearly; they were fragmented, vague about the cause of previous problems with the O-rings, and unconvincing about the link between O-ring failures and temperature. In other words, the engineers did not turn their data into sufficiently useful information, information that would make the right decision irrefutable.

Of course, the bad decisions of January 27–28, 1986, were not entirely due to communication failures; the expense and waste of aborting a launch at this very late date no doubt weighed heavily on the minds of NASA management, and eventually even the MK engineers were persuaded to think more like business-minded managers than like engineers primarily concerned with safety. But decisions can only be made on available information, and the more clearly that information is presented, the better the chance of making a good and safe decision.

Why is it your job to create information that people can use? Isn't it your job only to design or calculate the technical solution to the problem? As a matter of fact, your professional responsibility extends to the use that people make of your solution. Most engineering codes of ethics begin with a statement about an engineer's responsibility to the people her work will presumably benefit. As an example, here is the first canon of the Code of Ethics of the American Society of Mechanical Engineers:

> *Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.*

For every decision you make as an engineer, every design, process or product to which you contribute, you will need to keep in mind your obligation to protect "the safety, health and welfare of the public." That obligation must be "paramount" in all you do.

If you shirk your professional responsibility to communicate data in language and visuals that your audience can understand, then you are failing to live up to this code. Much of the investigation in the aftermath of the Columbia (2003) and Challenger (1986) space disasters focused on failures to commuicate technical findings appropriately to decision-makers. In both cases, the wrong decision was made; the Columbia attempted to re-enter the earth's atmosphere without its damaged tiles having been replaced, and the Challenger was launched in cold weather and exploded a few seconds later. You can learn more about the role of inadequate communication in