THE MIT GUIDE TO SCIENCE AND ENGINEERING COMMUNICATION

SECOND EDITION

JAMES G. PARADIS

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second edition

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Preface to the Second Edition

In the five years since the first edition of this book was published, the practices of science and engineering communication have been transformed by computer technology. The distinctions between memoranda and letters are now blurred, and most correspondence is transmitted electronically. Proposals are submitted on-line, prepared with templates downloaded from agency Web sites. Reports are distributed to clients through intranets, and their content includes video and sound as well as traditional tables and figures. Journal articles are increasingly written for full electronic transmission. Conference abstracts are submitted through the Web sites of professional societies, and oral presentations are supported by computer-based slide presentations and later uploaded to an organizational Web site, available for review to interested parties who were not present at the conference. Résumés and curricula vitae are routinely submitted through e-mail and posted on the Web.

Writers in science and technology "attend" network meetings, use the information resources of the Internet, and have personal as well as organizational home pages. They work in companies that have replaced multivolume manuals with information provided on CD-ROM or the Web, perhaps to field technicians who use handheld computers at remote sites. They have ongoing relations with readers, providing updates rather than waiting for formal requests, participating in electronic conversations about their work, revising documents when better information becomes available. Every chapter of this second edition of *The MIT Guide to Science and Engineering Communication* reflects these changes.

The materials in this book are drawn from our teaching of scientific and technical communication to two different audiences. As faculty members at the University of California, Santa Barbara, and at the

Massachusetts Institute of Technology, we teach communication to engineering and science majors. As trainers in seminars in industry and government, we instruct scientists and engineers in professional settings. The materials we use in this book will, we hope, bridge the gap between the university novice and the seasoned professional.

Our approach is to emphasize specific processes and forms that will help individual writers create documents. We recognize, however, that writing takes place in the social context of local groups and larger organizations. Most writing in science and engineering is collaborative. Coauthored documents are cycled through editing and review and then often issued with a corporate name as author. Collaborative writing influences nearly every phase of the process; finished documents represent the work of many people.

Throughout this guide, we make a special effort to provide realistic examples from actual documents and situations. Most of our examples have already been used in college classrooms and professional seminars. Our experience is the basis of our book.

Acknowledgments

We are grateful to the many teachers, colleagues, and clients who have taught us, read our manuscripts, furnished examples, and given us advice. We appreciate the insights and concrete suggestions given us by our students at the University of California, the University of Washington, and MIT over the past two decades. We appreciate the support and advice of MIT Press Editor Larry Cohen and the skillful artwork prepared by designers Stephanie Simon and Jim McWethy.

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We are also grateful to the many engineers and scientists at sites including The Applied Physics Laboratory (University of Washington), Brookhaven National Laboratory, the Department of Interior, Department of Energy, Exxon, and Mitre Corporation for teaching us about the roles communication plays in the work of professionals.

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Part I

1

Writing and Work

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Consider this situation. A research group carries on an informal discussion with colleagues and management. Through the discussion, the group develops an initial concept for a new coal atomization process. This concept is presented in an in-house proposal to local management and then as a detailed proposal to a government sponsor. The project is funded, and the ideas are worked out in greater detail. Text, figures, and tables are recorded in researchers' notebooks and computer files. Some of this material furnishes the computer graphics for Thursday afternoon in-house seminars. Later still, the same notes, data files, and figures are recorded and circulated as progress reports to the sponsor. Eventually—after still more informal discussion, progress reports, and meetings—aspects of the researchers' coal atomization process take shape as one *or more formal reports, journal articles, process specifications, patent applications, and design standards. Along the way, the group will have generated a good number of administrative and technical correspondence, most of it in the form of electronic mail.*

The most effective scientist or engineer is typically a skilled writer. Communication skills are so essential to sharing the results of science and engineering that writing often becomes a large part of any job. As engineers and scientists move up the organizational ladder, to supervisor and then to manager, they spend more and more time on communication tasks, reviewing and editing the writing of their subordinates as they assume responsibility for meeting group objectives and deadlines. Independent consultants spend still more time preparing documents for their various clients.

Engineering and scientific communication is a fluid activity. Writing extends and complements other forms of work. It helps to shape and share thought processes, research records, specifications, decisions—anything that can be represented in words, symbols, or graphics. Documents are records of the steps of decision making, design, reasoning, and research. Writing is the preeminent means of transferring information and knowledge in detail and accuracy.

The Social Context of Scientific Writing

Scientific writing is social in two senses. First, it is typically collaborative, the result of teamwork among peers and management. Second, the written document itself circulates in a community of specialists. An internal review process helps writers shape information into useful arguments that address their projected readers. Collaborators may be colleagues, supervisors, or outside readers. They may contribute to the finished product. They may provide comments and information. Or they may guide and evaluate the work.

The reviewing process, as shown in Figure 1.1, has different implications in different environments. Student writing, for example, is rarely true collaboration and has no audience beyond the instructor. This way of learning sometimes leads the novice to underrate the importance of writing in the professional world. Workplace writing, on the other hand,

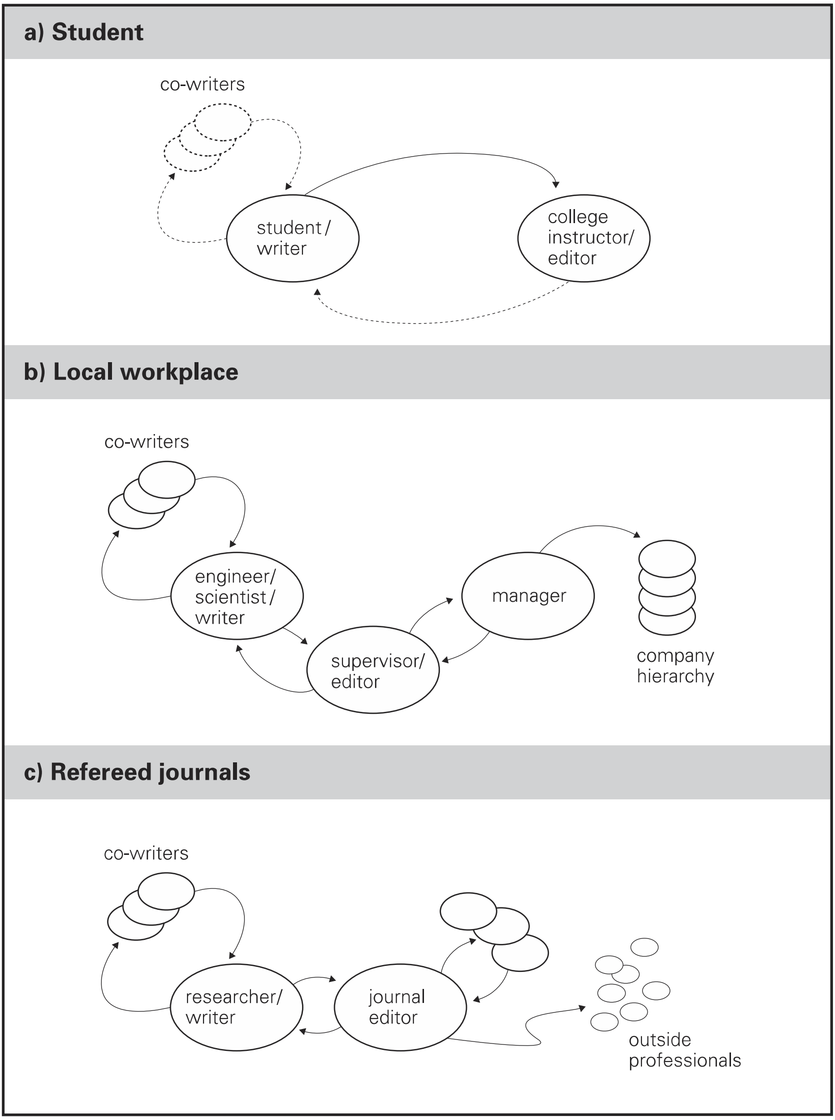


Figure 1.1
Three kinds of review cycles: (a) student to instructor, (b) employee to management, (c) writer to editor by way of expert referees. Student writing generally has no audience beyond the instructor; after supervisory review, workplace writing reaches company hierarchy; publications in refereed journals reach a wide audience of professionals in the same field.

is generally examined by both colleagues and a supervisor, who edit for content and style. In formal publication, the document passes outside the institution to a professional editor, who circulates it to referees and may ask for revisions.

The Politics of Written Communication

Most writing will have some political significance, quite apart from the primary message. To write is to assert, and assertions involve other people's interests. Your information may be accurate and your argument worthy, but you can still make big communication errors. Writers often do not appreciate the extent to which their activities impinge on the interests of others, whether in focusing a problem, developing a document plan, or drafting, revising, and producing a manuscript. At each of these stages, a writer needs to consult colleagues and supervisors—and perhaps to rework the initial efforts in order to develop an improved strategy for persuasion. The formal, permanent aspects of a written document may be inappropriate when a more personal touch is required or when a record isn't really needed. No matter what the technical merits of a written proposal, it may seem confrontational to management if the writer has neglected to build consensus in advance, through individual or small-group meetings. It is not always wise to rush an idea into document form; time can often be better spent discussing ideas and perhaps being prepared to share credit for innovations.

Recording as the Basis for Writing

It is sometimes tempting to think that comprehensive research precedes all writing. This is clearly not the case. Numerous writing and information-gathering activities take place while research is carried out, and these activities, in turn, furnish the basis of all project-related writing.

Consider a research project in which a physicist, physician, and medical technologist conduct a five-month series of experiments to study the pattern and extent of lithium distribution in sections of human brain. The investigators collect over 20 recent papers on lithium treatment of mania and depression, nuclear analytical procedures for analyzing lithium distribution, and modes of lithium action in rodent brain tissues.

They use a high-frequency beam reactor to bombard human brain tissue samples with neutrons, which cause a lithium isotope in the brain to release energetic particles.

They fill several notebooks with the details of the experimental design, methods of preparing cross sections of brain tissue, inscription records of the cross sections, data from particle detection, data reduction and rough graphs, notes on error analysis and sensitivity ranges for the experiment, and case histories of deceased patients who had undergone lithium treatment. Funded by a national health foundation, they are expected to prepare a report and to publish two or three papers on their findings in refereed journals read by clinicians and health researchers.

Like most research projects, this one generates an immense—and potentially chaotic—volume of written and visual detail long before any formal write-up of results takes place. The detail is a combination of previously published papers, a proposal, correspondence, photographs, spreadsheets, graphs, patient records, notebooks, and notes from meetings and informal discussions. This thicket of information needs to be sorted and arranged so that its patterns can be studied and it can be retrieved when necessary.

Effective writing requires initial organization, a task that writers sometimes underestimate. When information becomes available, you need to preserve it. The articles or reports you fail to file, the comments you do not record, the meeting notes you lose, the data you don't get around to entering, the files you fail to organize in the computer, the procedure you forget to write down—any of these lost or neglected items can haunt the researcher-turned-writer. Even small items—a missing reference, a physical constant, a procedural description—can turn a routine writing task into a guessing game. The failure to organize information as it's gathered accounts for many of the problems writers experience.

Planning a Recording Program

A program of information gathering, recording, and archiving is a way of anticipating the written and oral presentations that will inevitably follow. The ability to get to the various sources of information is essential to solving problems. Your design for arranging and storing material will save hours later and may well save you from having to reconstruct events from an incomplete or vague record. Here are some suggestions:

- Design a system that will arrange computer files for anticipated use in writing.
- Arrange published materials, correspondence, and other collectibles in file folders, loose-leaf folders, and vertical files.
- Keep a record of all meeting notes and agendas for future reference.
- Record experimental procedures, details, notes, and procedures in routinely updated laboratory notebooks.
- Sketch and arrange preliminary graphics in laboratory notebooks and computer files.

Using Notebooks

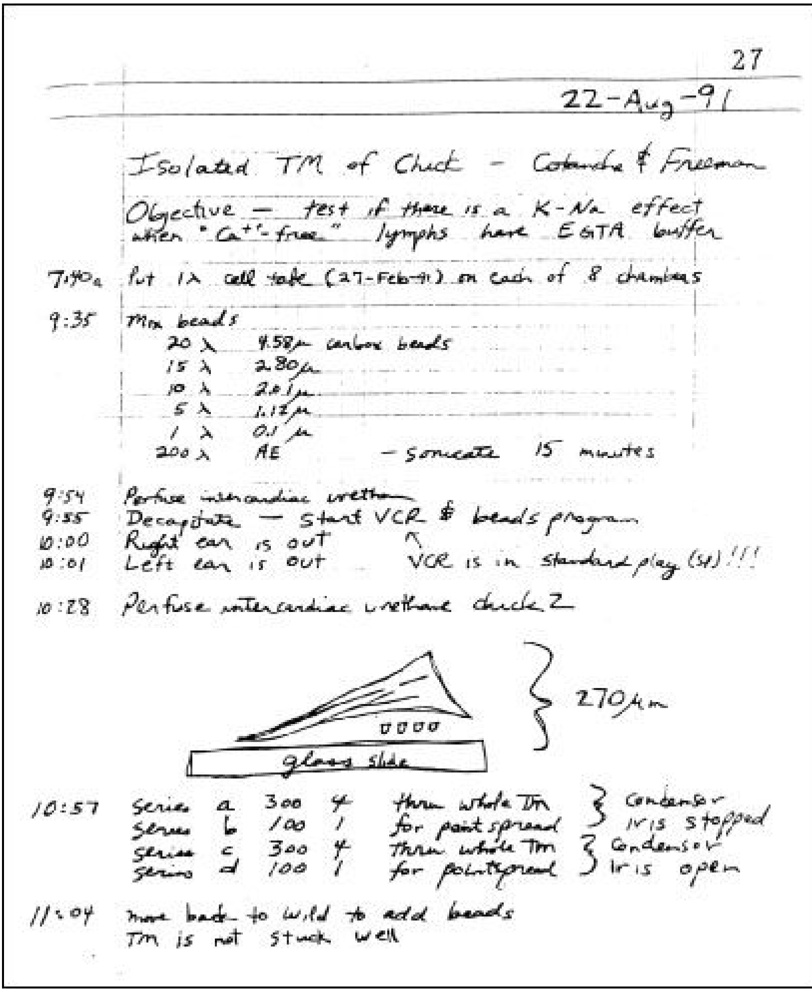
Although organizing records of your accumulating work may at first seem like drudgery, your records and files do assume great value with time. They are your personal store of information, extensions of your memory (Figure 1.2). Records require you to sort information conceptually. What is included and what is left out are matters of great significance.

Systematically kept, your notebook preserves the content and sequence of your activities. Your notebook makes it possible to reconstruct project developments. Always date the pages. A research record in a permanently bound notebook with printed page numbers is also a legal record of ideas, drawings, or descriptions. Maintain vertical files for material that does not fit in the notebook. Drawings, photographs, blueprints, equipment specifications, computer printouts, and calculations are all worth saving.

Items commonly recorded in notebooks include:

- Objectives: the purpose of an experiment and the time of day of the experimental activity
- Procedures: rough descriptions, sketches of apparatus, modifications to apparatus, steps in the procedure, notes on equipment and materials used
- Results: columns of data, rough graphs, descriptions, observations, photographs, printouts
- Analyses: equations, narrative comments, unanswered questions, data reduction techniques, new ideas, references to the published literature, correlations of data

Project record keeping is crucial. Laboratory notebooks may be subpoenaed in court cases that concern experimental or design questions.



27

22-Aug-91

Isolated TM of Chick - Cotanche & Freeman

Objective — test if there is a K-Na effect
when "Ca++-free" lymphs have EGTA buffer

7:40a Put 1λ cell tak (27-Feb-91) on each of 8 chambers

9:35 Mix beads
20 λ 4.58μ carbox beads
15 λ 2.80μ
10 λ 2.01μ
5 λ 1.17μ
1 λ 0.1 μ
200 λ AE — sonicate 15 minutes

9:54 Perfuse intercardiac urethane
9:55 Decapitate — start VCR & beads program
10:00 Right ear is out
10:01 Left ear is out VCR is in standard play (SP)!!!

10:28 Perfuse intercardiac urethane chick 2

10:57 Series a 300 4 thru whole TM } Condensor
Series b 100 1 for point spread } iris stopped
Series c 300 4 thru whole TM } Condensor
Series d 100 1 for point spread } iris open

11:04 move back to wild to add beads
TM is not stuck well

Figure 1.2
Notebook entries for experimental study of laboratory chick specimens. Note the statement of experimental objective and the linkage of time and action. (Courtesy of Professor Thomas F. Weiss, MIT.)