Integrating Writing into Technical Courses: Steps toward Incorporating Communication Into the Engineering Classroom

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Abstract: This paper presents a process for use by engineering faculty who wish to develop effective writing assignments for technical courses. The process is based on the design process, something with which engineering faculty are very familiar. In addition to the process, the authors offer background information regarding audience analysis, assignment development, and evaluation techniques; these aspects should help interested faculty avoid the common pitfalls associated with assigning and evaluating writing.

Introduction

Since the adoption of the ABET EC 2000 and the emphasis on outcomes-based education, the number of engineering faculty who assign writing in their technical courses has increased significantly. Recent issues of *Technical Communication Quarterly*, *IEEE Transactions on Professional Communication*, and *Journal of Engineering Education* document the efforts of engineering faculty working in teams with technical communication faculty to develop writing assignments.[1-4] We found similar evidence when we informally surveyed engineering faculty who attended communication workshops we conducted at the American Society for Engineering Education during 1999 and 2000. Participants described a wide variety of communication tasks and discussed their experiences in making writing a component of an engineering course. From the surveys, we concluded generally that engineers introduce communication into their technical courses for three reasons:

1. Writing assignments not only help students improve their ability to communicate within the engineering discipline, but also serve to increase their understanding of engineering concepts.
2. Engineering faculty feel strongly that communication will be an important asset to students in their future work as engineers.
3. Meeting ABET requirements necessitates the incorporation of communication skills development in courses within the engineering major, not just in one specified course in technical communication.[5]

This empirical evidence is also supported by recent research in composition studies. Not only do such experiences help engineering students see the value of communication for their future careers, but writing in the engineering classroom also introduces students to the modes of communication that are appropriate to the field of engineering. When the engineering professor assigns lab reports, project proposals, and design reports, students learn to communicate from a practitioner of engineering communication, that is, the engineering faculty member.[6]

Despite the documented advantages to incorporating writing in the technical classroom, many engineering faculty discover significant obstacles that prevent them from attempting it, or discourage them from continuing in the effort:

1. Many engineering faculty find that there is too much work (i.e., reading, grading, commenting) involved in assigning and evaluating writing.
2. They also have encountered problems in developing effective assignments that both emphasize engineering concepts while encouraging good writing.
3. They are disappointed with the writing that students submit for evaluation. Often it seems that students have submitted a first draft attempt of the assignment (and they probably have) with no attempt at revision.
4. Some faculty believe that they will spend so much time on writing that they will have to neglect important technical content that must be covered in the course.
5. Few engineering faculty find support for their efforts—release time, consultation with experts, etc.—in department or university administrations, or from English or technical communication faculty.[7]

Our purpose in this article is to address these obstacles through a detailed process. In a series of specific steps, we model the elements that should constitute developing, assigning, and evaluating writing in technical courses. A self-evaluation checklist accompanies each step. These checklists will assist engineers working on communication assignments to verify that they are not falling into the common problems associated with bringing writing into a technical course. We discuss the process of producing both a brief writing assignment and a substantial writing assignment. In order to make the process widely applicable and helpful, we have included suggestions we believe will improve any writing assignment under development.

Step 1: Select technical topics in appropriate courses

Designing effective writing assignments starts with the client; in this case, you as the engineering faculty member are the "customer." In the current climate of engineering education, many of us are accustomed to identifying the student or industry as the customers we serve. In the case of writing assignment design, however, the faculty member is initially the customer because your needs as an instructor—to teach particular principles, assist students in achieving certain learning outcomes—must be the starting point. Without such consideration, you may find yourself at the end of the process complaining, "But that isn't the writing assignment I wanted!"

In order to determine the appropriate target for your design work, complete Checklist 1:

CHECKLIST 1
• List the topics/objectives covered in a few of the courses you teach.
• What concepts covered in the course could become writing assignments? Be sure to distinguish minor assignments from major assignments.
• Choose a concept/objective which students can write about to enhance their learning.
• Articulate the purpose of the assignment.

Step 2: Specify assignment features: purpose, length, guidelines, value of writing

Engineering instructors need to correlate the specifications that serve their pedagogical goals to the kinds of writing assignments they can develop. In particular, you should decide what purpose the assignment will serve and how it complements and strengthens the course content before incorporating a writing assignment into a course. What do you want your students to gain from the experience? If you have not determined this for yourself, your students will have difficulty completing the assignment satisfactorily. Grading will become an even more difficult, time consuming challenge.

The length of writing tasks you assign is directly linked to the purpose. Do you want to students to read and summarize an article you have on reserve in the library? Interpret it? Evaluate it? Compare it to another article? Do you want students to conduct laboratory research and compare their results to theoretical ones? Purpose can determine length. Short writing assignments work well for freshmen who have little technical knowledge or engineering background. As students mature intellectually and complete advanced courses, they are more ready to tackle larger, longer, and more complex projects. Complexity does not necessarily mean a longer document. Short writing assignments (2-3 pages) can deal with difficult concepts as readily as 20 page reports.

You should also be forthright in offering direction on narrowing a topic. Many students need your help to define a manageable, focused topic. A student faced with a set length—say 10 pages—often sees the task as huge and as a result selects an enormous topic that could not possibly be covered in 20 pages, much less 10 pages. All too often what results is frustration for the student and the professor.

Giving students clear guidelines is important with any length assignment. Telling a student to "write" or "discuss" is too abstract, and you may get just what you ask for — a long rambling discussion. If, however, the assignment is more targeted—"compare, evaluate, classify"—you are more likely get something interesting and worth reading.

The following assignment, given to students in an introductory lab course, illustrates exactly what dangers can result when the instructor ignores the demands for clarity and how the lack of it causes great frustration for students.

> Lab Report 1 Assignment:
>
> Your lab instructor will specify the date and time your lab reports are due.
>
> We strongly urge that you make use of the Campus Writing Center in preparing your reports. Simply take the draft version of your report to the Peer Tutors and have them critique it.
>
> The form of the report should generally follow the guidelines used by anyone wishing to submit a scientific paper for publication.

This example highlights several problem areas. First, the instructor has not identified the purpose of the assignment for the students. Although the purpose of a lab report may be assumed to be clear for the instructor, students need to know why they are being asked to write a lab report, i.e., what concepts, principles, theory are they being asked to illustrate. Second, students have also not been given specific guidelines regarding the document they are to produce. Instead the instructor feels that "guidelines used by anyone wishing to submit a scientific paper for publication" is adequate direction. Unfortunately first-year students (for whom this assignment was made) have little familiarity with scientific journals, nor are they at the stage where they could reasonably expect to publish their work. Finally, the instructor expects the campus writing center to "fix" any problems the students may have with writing. The message to students is clear: the instructor places little value on writing. Contrast this assignment with the assignment in Appendix A.

The last issue is perhaps one to which engineering faculty should pay particular attention. In order for students to understand that writing is important to you, you must spend class time devoted to writing and discussing writing. Provide multiple opportunities for students to write. Even a 10 minute response assignment at the beginning or end of class allows students to see the value in synthesizing what they learn. Perhaps ask students to summarize the day's class discussion or pose a question about a topic they didn't fully understand. The important thing is that students see that you value writing and that it is an important component in their engineering discipline.

The same message, that you value good writing, will be evident to your students in how you evaluate their work. Rather than separating a student's grade into two parts—one grade for technical content, one for writing—you can show students that writing is integral to communicating technical information by tying writing to content. Technical professors play an integral role in establishing the importance of writing campus-wide. Subtle lessons about the role of writing can easily be incorporated amidst the formulas and free body diagrams taught in an engineering course. Technical faculty do not need to be able to recite comma rules by heart or feel responsible for teaching the fundamentals of paragraph development. Instead, faculty should be good role models, emphasizing the importance of students being able to communicate their technical knowledge through writing.

Step 3: Specify document type

One of our tasks as designers of writing assignments is to clearly indicate the document type students are expected to produce, and to give them guidelines for producing such a document. Common document types include memos, lab reports, project proposals, essay exams, and technical reports. Instructors who specify a particular document type, rather than merely indicating that the students should write "a paper" on a particular topic, will be more pleased with the products they receive. You can achieve further quality control by offering the students examples of the specified document type and/or explaining its conventions, the "rules" that experienced writers follow when producing a document of this type.

For example, you may have decided that you want students in a civil engineering freshman design course to write about making a parking lot handicapped-accessible in order to deepen their understanding of the competing factors involved in such a design venture. The instructor may tell student groups to submit project proposals. Proposal quality can be improved by showing students examples of project proposals, and by explaining that such proposals should include elements such as intended plan of action and time frame. These elements may be

contrasted to a project progress report that emphasizes different, albeit accurate, information but does not fulfill the needs of the client in the project's initial phases.

A beneficial brainstorming exercise for faculty is to generate a list of document types that might conceivably be assigned in your courses. You can do this by asking yourself what forms professionals and academics in your field use to communicate.

CHECKLIST 2
• Generate a list of document types which are used to cover that material (e.g., essay, lab report, project proposal, etc.).
• Given the constraints (length, time, applicability, student level), decide which form works well for this choice.
• Think about the audience applicable to this form.

When we engaged in this activity at our ASEE workshop, the faculty members present were able to generate in just a few minutes a large list of possible document types, ranging from feasibility studies to web pages to poster presentations.

Step 4: Identify and accommodate intended audience

Closely linked to the need to specify document type is the importance of identifying and accommodating the intended audience for the document. A writing assignment should specify a particular communication situation within which the students must work, as illustrated in the following graphic:

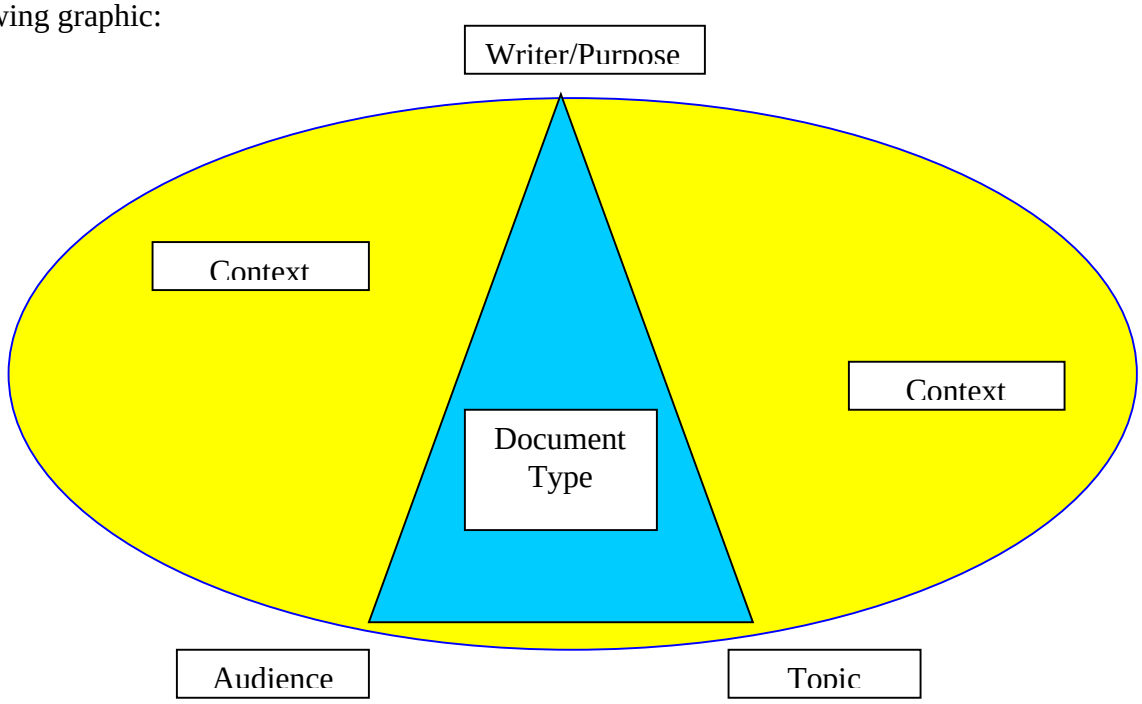

Figure 1: Communication Situations

As the graphic shows, all communication situations include a writer with a purpose speaking about a particular topic to a given audience within a particular document type against the background of some wider context. For example, in the previous example of project proposals

for first-year civil engineering students, you may have decided that you want students (the writers) in a civil engineering freshman design course (part of the context) to write about making a parking lot handicapped-accessible (topic) in order to deepen their understanding of the competing factors involved in such a design venture (purpose).

Designers of writing assignments must keep in mind that every piece of communication has an audience, real and/or intended readers of the documents we ask our students to produce. Documents are more successful when they are shaped with the characteristics of the particular audience in mind—characteristics such as age, interests, probable use for the document, and expertise. To take expertise, for example, the writer should carefully consider the readers' knowledge and experience level in the applicable subject matter. Are the readers experts? Novices? Lay people? Answers to these questions should affect the writer's decisions about everything from content selection to word choice.

The brainstorming exercise for document types can also be extended into consideration of audience. Such lists of possible document types tend to break down into two overlapping groups: forms that are used primarily in academic settings to instruct or evaluate students (forms such as the essay exam and class lab report), and document types used by full-fledged members of a professional community or discipline (forms such as the professional society conference paper or the grant/funding proposal). It is helpful to think about whether the document type you are considering is primarily a student form or a professional form, and then to consider the "payoff."

As depicted in the triangular graphic showing communication situations, it is important to consider topics for writing assignments in conjunction with writer's (and instructor's) purpose, audience, and document type. Mapping out the relationship between each of these elements for a given assignment will give faculty greater control over both the students' written products and what they learn in the process.

CHECKLIST 3
• Create an assignment to generate the piece of writing you want.
• Explicitly address the document type, purpose, audience, length, and other constraints, in the material given to students.
• Create peer editing/grading sheets to accompany that written assignment, to be handed out with it, which will be used for final evaluation.

Step 5: Conduct peer review sessions

Focused peer review is an activity, performed either in or out of class, that asks students to evaluate each others' writing to determine if the work meets the assignment specifications at an early stage of the document's development. Focused peer review offers several advantages to both student and instructor:

- In the process of reviewing the work of others, students see models of how the assignment may be completed. Students are generally quite adept at distinguishing between good documents and bad, or comparing their drafts to other models.
- Focused peer review encourages students to revise their documents before submitting them to the instructor for final evaluation. Comments from peer reviews can guide students' revisions of their documents.

- Instructors are generally more satisfied with the final documents they receive, since the peer review work has provided a forum for students' first drafts.

Focused peer review may be conducted in a variety of ways, but the following principles provide practical ground rules. Generally it is a good idea to assign students to peer review groups. This practice allows you as the instructor to identify the strong writers and put them into groups with weaker writers. The review may be conducted in or out of class, but out of class review sessions must be carefully managed. You may decide to grade the peer review work of students, but expectations and outcomes for the session should be clearly explained to students. Students cannot make the most of focused peer review without an accompanying rubric, a set of expectations of what they should be concentrating on in a particular document. Without a rubric, they will normally give a very superficial evaluation of the document, such as either finding all the comma errors or saying that the document is good. In designing the rubric, consider the questions you want answered regarding the document, as well as questions students may have regarding the assignment:

Peer Review—Process Explanation
Introduction

The author defines the process. The terms used to define the object that are clear, precise, and avoid double meanings. The author states the purpose, goal, or application of the process. A list of the major steps in the process is provided.

Process Explanation

The author defines or explains step 1. The author states the purpose or goal of step 1. Step 1 is related to step 2. Each subsequent step is explained using the same pattern of organization. The steps are consistently related to the purpose, goal, or application of the entire process.

Conclusion

The author concludes the explanation by increasing the reader's understanding of the sequence, theory, or applications of the process.

Visual

The visual gives a clear illustration of the process. The steps listed in the introduction are labeled on the visual. The visual is not done by hand. The source for the visual is correctly documented. The visual has been given a caption or title.

Describe one strength of this draft:
Describe one weakness of this draft:
Suggest one revision you would make if this were your draft:

Figure 2: Evaluation Rubric for Process Explanation Assignment

The important thing is not to ask students to review too many elements of the document at one session. You should limit the review to issues of significance to the student's work at this stage of the document development process. Emphasize to them that issues such as grammar, spelling, and punctuation should be addressed later on in the process, after they have successfully accommodated other concerns, specifically content, organization, and audience. Perhaps the most effective use of rubrics includes providing students with the rubric when the assignment is first made. Students then not only understand the specifications for the document, but also exactly how it will ultimately be evaluated.

CHECKLIST 4
• Create peer-review forms to address the two or three most important elements.
• Allow students to discuss their written responses with each other.
• Allow sufficient time for students to revise their work and incorporate the suggestions made.

Step 6: Allow students to revise their documents

The final version of the document should incorporate the comments of the peer reviewers, as well as any other feedback received from the instructor. The crucial concern at this stage of the document's development is ensuring that students have the time necessary to perform needed revisions. Scheduling peer review sessions on the final day of the course will not allow students time to reflect on reviewers' suggestions and attempt to incorporate them. Students may benefit from a second review session to determine how successfully they were able to revise their documents. They may also have follow-up questions for their reviewers that can help clarify a particular suggestion or revision strategy.

Step 7: Evaluate the final documents

Faculty usually dread evaluating documents. Grading can be time-consuming and frustrating for the instructor, or even detrimental to a student's development as an effective communicator. Problems at the evaluation stage may be caused by a poor assignment; essentially, because the purpose, scope, document type, and audience requirements have not been expressly defined in the assignment, the student has difficulty creating a document that meets the instructor's expectations. The problem may lie in the approach the instructor takes in evaluation, trying to overgrade the document. Overgrading takes several forms. Evaluating a student's document should not mean rewriting it. Faculty can spend inordinate amounts of time writing sentences and phrases in the margins, providing a version of the content that matches the instructor's expectations but does not reflect the student's manner of expression. Overgrading can also mean focusing on issues such as grammar, spelling, and punctuation and correcting each of these errors, in addition to correcting and/or revising problems with organization, content, and audience. When an instructor returns a student's document covered in red ink, the student is not naturally able to differentiate between significant problems and more minor ones. This can discourage the student from revising the document or attempting to improve her writing at all.

The rubric you develop in conjunction with the assignment can be of great help at the evaluation stage. Because you have distributed the rubric with the assignment and required peer reviewers to use it during their sessions, you can use it for your own evaluation of the document, as a grading checklist. Comments can be recorded on the grading sheet correlated to each particular

assessment criteria. Students can then differentiate between levels of error and the nature of the error you have identified.

CHECKLIST 5
• Evaluate the students' work and return.
• Address major issues of organization, logic, format, and readability.
• Address consistent grammatical and usage mistakes only once (e.g., "Consistent comma errors," "A number of garbled sentences.").
• Resist the urge to rewrite it for them!

Conclusion

Bringing writing into your technical courses may not require as much effort as you fear it will, or as much as you have experienced in the past. Even short writing assignments, completed in class, help students develop their communication skills. These exercises also ensure that students are learning through writing. Consider the suggestions below as ways to incorporate short writing experiences into your classroom:

WAYS TO INCORPORATE WRITING INTO THE CLASSROOM
• Take five minutes at the beginning or end of class for students to "freewrite" about the subject matter. This can be collected or not.
• Stop class periodically to ask students to summarize the key concept in one sentence.
• Have students summarize or write abstracts of key material.
• Periodically give students index cards to make comments, ask questions, give feedback. Write responses and return.
• Use peer review.

In the end, faculty in both engineering and English share a common goal: we want to prepare engineering students to work effectively in the professional world. For that reason, we can share in the important project of enhancing students' skills as engineering communicators. Just remember the following:

THINGS TO REMEMBER
• Major, or substantial, projects don't have to be "long." Remember that writing concisely is a skill engineers need.
• Grades for "writing" and "content" can't be separated. If it's hard to follow, the content gets lost; if it's well written but says nothing, it's not useful.
• Engineers are the best judges of effective engineering writing.

Appendix A

Sample Assignment: ECE 206 Winter 2001/2002 Term Paper Assignment

Professor Edward Wheeler, ECE Department, Rose-Hulman Institute of Technology

Throughout your professional lives, you will need to be able to learn on your own. The way people talk about this in engineering education is that we need to be lifelong learners. The ability to learn independently is vital because 1) the rapid pace of technological change will otherwise cause you to lose your competitiveness, and 2) your continued professional growth can only be supported by an growing knowledge base. Take time to really think about this. Wouldn't you honestly expect senior engineers--whether they are managers, executives, or entrepreneurs--to be current in their technical knowledge and, further, would also have developed a broad base of knowledge and experience? These things are precisely those that will be expected of you as professional engineers. You have likely heard the idea before, but it is nevertheless true: The world in which you will live will be one where knowledge is the primary source of value.

You will need to communicate. You need to be able to communicate well. This is often the area where engineers are weak. A person can be the most brilliant and insightful person around, but, unless they can communicate clearly and persuasively, their ability to effect change and be recognized will be seriously impaired. Being willing and able to effectively communicate is a vital skill and one that engineers simply must develop and use. To be convinced that the ability to communicate effectively is crucial for engineers one need only listen to leaders from industry, the military, and government. When asked, these leaders consistently list effective communication skills second—behind only creativity and broad problem-solving skills—as desirable traits for successful engineers and managers.

One of the crucial skills in effective communications is the ability to tailor your writing for a particular audience. The terms you use, the details you provide, and the necessary background information are strong functions of your audience. For example, your communications to a peer will likely be different from those to an industry leader and too be different from those addressed to a reader from the general public. In fact, as society becomes increasing dependent on technology, one can argue that engineers, scientists, and mathematicians have a moral obligation to provide clear, correct, and jargon-free discussions on technical topics.

In this assignment, you may choose from between two papers. For the first, you will investigate a technical topic with which you are likely unfamiliar. You will learn about this topic, essentially on your own, and then report your findings to a technically proficient person, but one who is not familiar with your specific topic. The second paper is one in which you report to a general audience on some interesting and important topic with which you are quite familiar. The topic should be entirely or partly within your discipline.

Option #1

Write a paper on one or two *specific* uses of transducers in measurement & control in your discipline.

1. Your introduction should inform the reader of the paper's topic and your goal in writing the paper. You could perhaps include a concise overview of your paper.

2. Provide a clear, complete, and accurate discussion on the physical principles of its operation. That is, *exactly* how does it work?

3. Give examples of its use. Give detailed examples. Two or three examples that are detail rich are more useful, and more interesting to read, than giving many examples that lack detail and depth. Examples are the "meat" of your paper; good examples can bring a discussion to life.

4. If at all possible, provide some historical context. How were they developed? What were early ones like? How do they differ from more modern versions?

5. Compare and contrast your transducer with ones that can sense the same physical variables? What are the strength and weaknesses of each?

Your first draft should be at least 3 pages long, not including the title page, with 1 ½ line spacing and 11-point font. Your final paper should be a minimum of 2 pages in length, not including the title page. It should have 1½ line spacing and 11-point font. References should appear as endnotes as per the examples shown in class. References and visual aids should *not* be included when determining the length of your paper

Audience

For this assignment your audience will be a person somewhat familiar with transducers and your discipline, but not specifically the topic you on which you write. That is, the person should be considered as technically proficient but not intimately familiar with the specific transducer on which you write.

One implication of this will be that you should feel free to use without definition many technical terms such as force, energy, velocity, viscosity, pressure, voltage, current, power, tensile strength, specific heat, etc. But, since you cannot assume your audience is intimately familiar with the specific transducer you discuss, you might not wish to use--if we were discussing infrared thermometers for example--terms such as Wien's Law or cavity effect without providing a clear definition. Also, we might not wish to assume that every reader would know that visible light is between 400 and 700 nm and that IR radiation has a wavelength longer than 700 nm.

Option #2

Write a paper on some important and interesting topic with which you are, or can become, knowledgeable. The topic must be partly or entirely in your discipline. The object in this assignment is to demonstrate your ability to effectively communicate to an audience having many members who are not technically oriented.

When writing and revising your paper, try to place yourself in the place of your potential readers. Place the topic under discussion in a larger societal context and make it clear to your audience why your topic is of interest to them. For example, discuss its history and past use. Discuss other techniques that are used to achieve similar ends. Explain the impact of the topic in other places,

perhaps in other countries. Discuss the global impact of the topic and its possible futures. Discuss its economic, political, or ethical implications.

To effectively communicate, that is, so that your voice will be heard, it is not sufficient to only be technically correct and proficient. You must also show that you are informed on a range of issues that might have some bearing on topic under consideration. My point is that, to write this type of paper and to do it well, is hard work.

Your first draft should be at least 3 pages long, not including the title page, with 1 ½ line spacing and 11-point font. Your final paper should be a minimum of 2 pages in length, not including the title page. It should have 1½ line spacing and 11-point font. References should be as endnotes as per the examples shown in class. References and visual aids should *not* be included when determining the length of your paper.

Audience

To be specific, consider that your audience is comprised of generally well informed members of the general public

The range in your audience is daunting--from lawyers to office workers, from brick masons to legislators, from school teachers to religious leaders, from judges to truck drivers, from scientists to artists, from engineers to business executives. You address a diverse group having an enormous range talents and knowledge. Do not assume, just because the topic interests you, that everyone will automatically share your interest. You should count yourself fortunate if they express interest in your topic by starting to read your work. You should further consider it a significant accomplishment if you are able to maintain that interest.

You absolutely should not talk down to such a group. Rather, your role here is to be clear and accurate. Your job is not to "dumb down" your discussion or to talk down to your audience. The job is a much harder one than that. It is to write so well that you are able to communicate clearly and accurately without the technical jargon that we so depend on when talking to other engineers and scientists. It is well known that to explain a complex topic simply, one must possess a deep understanding of the topic.

Hints

1. Do not wait until the night before the due date to write your first draft or to revise your first draft for the final paper submission. The secret to writing well is revision. It is tempting to think good writers do not revise their work, do not struggle to write well, and are able to write beautiful prose the first time out.

   Nothing could be further from the truth. *Good writers--engineers who write well, scientists who write well, mathematicians who write well--revise constantly.* Writing well is almost always the result of hard work.

2. In gathering material for your paper, seek assistance from a research librarian in the Logan Library. They have the necessary expertise to help you find good sources of information.

Due Dates

1. first draft due 1/25
2. peer-review due 1/29 (sign your peer-review)
3. final paper due 2/7

Please be sure to turn in all writing assignments—including the first drafts which have been peer-reviewed and peer-review worksheets—with your final paper.

- peer-reviewed first drafts (there should be two of them)*
- peer-review worksheets (there should be two of them)*
- final paper

*****Unless you are on the team with two members. If you are you will only on one peer-reviewed first draft and one peer-review worksheet.

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Biographical Information

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